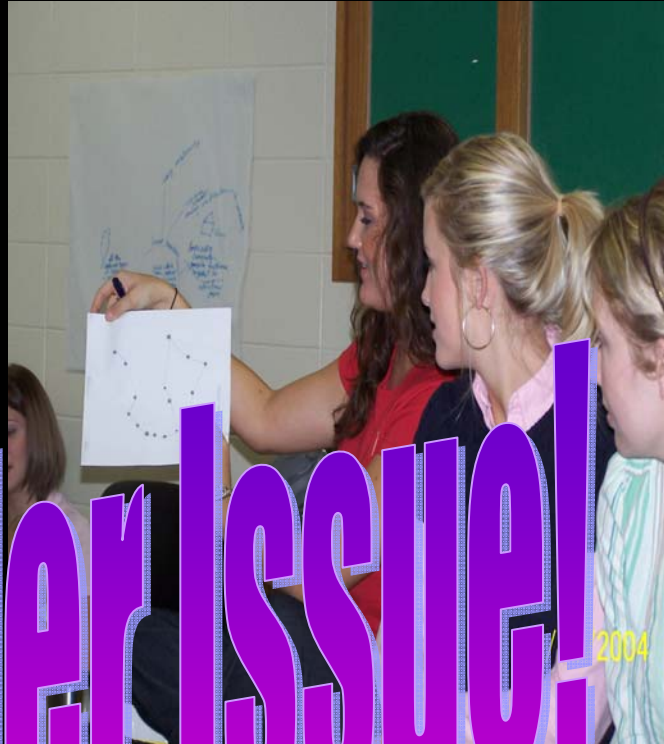


# *the CLASSROOM ASTRONOMER*



# Free Sampler Issue!



*THE MAGAZINE ABOUT TEACHING  
ASTRONOMY*

## Welcome to My Universe!

Probably you already live here. This is the Universe of the classroom teacher, the person who delivers the Sun, the Moon and the stars to students from kindergarten to undergraduate college.

This magazine is an outgrowth of a research finding that classroom astronomy teachers have no publication to call their own. Articles on the practical aspects of astronomy teaching rarely appear in the larger science education magazines. The popular astronomy magazines have long since given up on covering much astronomy education, too. Thus was born the idea of this magazine, where teachers will find useful, practical how-to information, how to get astronomy concepts into the minds of students. It is not an astronomy education research magazine, though research can inform the process.

I queried several dozen high school astronomy teachers about what articles they'd like and they replied: info on low cost labs for the classroom, classroom teaching techniques—lessons that work well, ideas that get a concept across, strategies, mnemonics. Also, what can be done to use the sky events for teachable moments, and more. While nominally centered on high school, teachers at elementary/middle and college are welcome in this universe, too. Astronomy, from K to U...

In your hands, or at least the digital tablet, phone, computer or other device in your hands, is this sampler, an 16-page selection of the various kinds, topics and grade levels of articles and columns we publish in our 24-pages-and-up normal issue. I hope you like the publication and subscribe in the digital, PDF or print form(s) of your choice! In another free file is an index of all articles published, by astronomical area, so you can purchase back orders as well! Enjoy.



*Dr. Larry Krumenaker*

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# Eye Spy - Visual Spectroscopy and the Borders of the Colors

## - Larry Krumenaker

A common spectroscopy lab looks at gas tubes. Here's an uncommon lab looking outside at a light bulb and inside at the eye!

My students were streaming into the classroom set up with various gas tubes and hand spectrosopes outfitted with scales to measure wavelengths of the gases' emission lines. I even had two ways to show absorption line spectra we could measure. But what can I do about the third kind of spectrum—continuous—besides, well, show it? How unscientific! How non-inquiry! How do I do something with it? Answer: Tell a lie.

The falsehood was brilliant, if I do say so myself. We all were looking at a regular tungsten incandescent light bulb, seeing its rainbow. "Everyone see all the colors?" "Yes, Mr. K." We rattle through ROY G BIV (the "I" part was a small problem). "OK, so how do you know where red is?" Then the little imp inside my head spoke up. "Students, I want you to measure—independently, you all have your own eyes—where red becomes orange, where orange becomes yellow, and so on, and also where both red and violet turn to black. Yes, I want to know where the borders of the colors are. Go to it!"

Of course, the lie is...there aren't any borders to the colors. That's why it is called continuous. But this got them moving, me out of a dilemma and all of us learned some things we didn't even suspect.

	A	B	C	D	E	F	G	H	I
1	<b>Borders of the Colors</b>								
2									
3	Observer	Black-Red	Red-Orange	Orange-Yellow	Yellow-Green	Green-Blue	Blue-Indigo	Indigo-Violet	Violet-Black
4									
5	black to red	red to oran	orange to ye	yellow to green	green to blue	blue to indig	indigo to vi	violet to black	
6	650	600	590	560	490	460	440	400	
7	670	590	560	550	490	440	420	410	
8	750	600	590	550	490	470	450	425	
9	710	615	600	550	500	450	430	400	
10	650	670	550	565	490	450	425	440	
11	665	600	575	560	515	470	430	400	
12	660	620	590	560	540	510	460	430	
13	600	665	560	555	490	440	420	440	
14	680	602	600	570	500	470	450	410	
15	650	605	585	570	510	450	435	410	
16	665	620	595	570	510	480	450	580	
17	650	600	590	570	490	460	450	400	
18	665	600	590	570	510	470	455	400	
19	690	630	610	570	510	480	450	420	
20	650	600	590	550	550	490	450	400	
21	650	620	560	565	500	475	430	380	
22	645	605	590	550	480	475	460	420	
23	650	600	575	560	510	480	430	400	
24									
25									
26									
27									
28									
29									
30									
31									
32	664	613	583	561	504	468	441	420	
33	31	22	16	8	18	18	13	43	
34	red	orange	yellow	green	blue	indigo	violet		
35		50	30	23	57	36	27	21	

Figure 1. Data spreadsheet for determining the places where colors 'change'.



## Where Are The Borders?

I quickly opened up a blank spreadsheet, put in some column titles for each border and the students began, one by one, to enter their data. It became evident that the students weren't all getting exactly the same values. This was a good way to introduce (or reinforce for those who knew it already) that all measurement is not exact. Figure 1 shows the data as was input into the spreadsheet

What became more interesting was to add to the bottom of each column the basic statistical functions of Average and Standard Deviation. Even if the students don't know the latter it is easy to explain that this is a way to measure the variation in the individual data values.

The statistics told us three things. First, the student data has some randomness to it, but our averages (means) were pretty consistent. Second, all our randomness wasn't equal. Some borders were determined more precisely than others. Last, all colors weren't equal in size.

Figure 2 shows two measures (the purple curve was added after I did some research). It seems that the most accurate value for a color border was right smack in the middle of the spectrum, around the green-yellow zone. Hey! Isn't that where the Sun's peak radiation is? I guess then we must have adapted to it as a species for our best visual acuity! And, clearly, our eyes should get less acute as we move out into the red and violet ends of the spectrum. The data bears that out—it gets less accurate (the standard deviations generally increase) in both directions. Our measurements' inaccuracy doesn't measure just

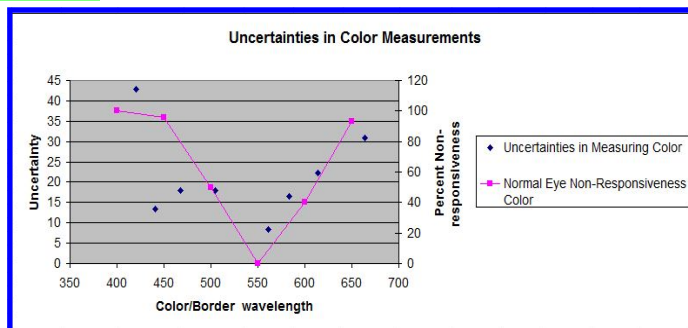


Figure 2. Color border uncertainties (blue) and the eye's color response curve (purple).

our human fallibility, it also measures the color response curve of the human eyeball. And, as a bonus, it shows that one person couldn't possibly determine this alone, it takes a group to make independent measures that are looked at together, a classic 'scientific method' way of doing science.

Last discovery...the three biggest colors were Red, Green and Blue (or Blue-Violet if you left off the Indigo that is very narrow). RGB. Why are they the largest? Because these are the colors to which the eye's retinal cones are most sensitive! Because of this, televisions and computer monitors use technologies that only produce red, green and blue tones, and by varying them create the illusions of other colors. The technologies of our modern age hark back to how our eye works, how it adapted to the Sun's light, and is detectable by a group effort in measuring something....that isn't actually there!

### Hand Spectroscopes Have Their Issues

Not all error is random and not all spectroscopes

are properly made. There are two basic hand spectroscopes with back-lit scales for measuring wavelengths on the market. One is a fairly inexpensive, cut-off triangular shape (Figure 3) with the far end containing a slit to let the light in and a flat piece of film with a scale on it. The opposite, squared-off point-of-the-triangle has the clear plastic diffraction grating that you look through. The more expensive, but sturdier made, Project Star spectroscopes operate similarly but the plastic film with the imprinted scale is curved into an arc. In both types, you aim the slit at your light source and view the spectrum off to the side inside the spectroscope box. You'll see several spectra, to the left and right, and often two spectra per side, but the only one that matters is the one viewed on top of, or immediately above or below, the backlit scale. The simplistic scope has the numbers 4, 5, 6 and 7 which stand for the thousands of Angstroms or hundreds of nanometers (take your choice of units) for the wavelengths you are seeing. The individual lines between them are 10% of the scale.

The problem with the flat-scaled spectroscope is that as you view the greater wavelengths (red colors) the measures get more systematically inaccurate. As light is diffracted by the grating, the colors are spread out according to wavelength and the sine of the angle. For small angles, the value of the sine is about the same as the value of the angle (in radians, not in degrees). But at the red end of the spectrum, the 'equality' breaks down; the scale is still linear but the spreading is not, so your measurement becomes increasingly erroneous, except for Project Star's 'scopes. Their curved film takes care of the problem.

This isn't entirely a bad thing. In the real world, scientists have to determine their systematic errors as well. It's called calibrating your instruments. You have to know something else is accurate, and measure your values in your new scale against the known values.

You can calibrate your spectroscopes by measuring lots of known emission lines. Have your students

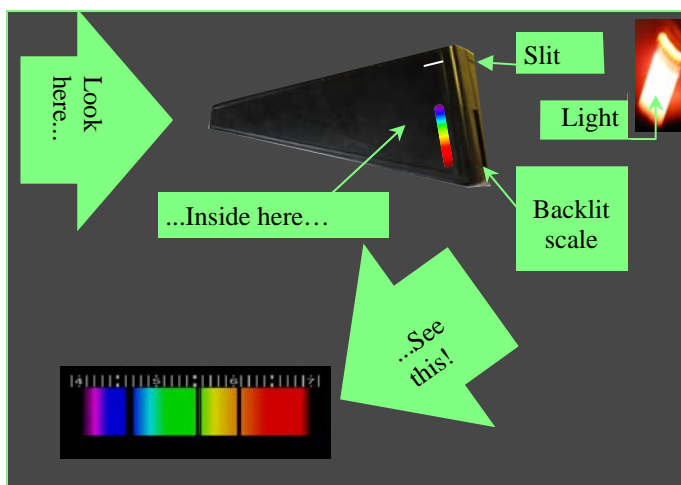


Figure 3. Anatomy of a hand spectroscope.

### Helium Lines Mercury Lines

- 668
- 588
- 502
- 492
- 471
- 447
- 439

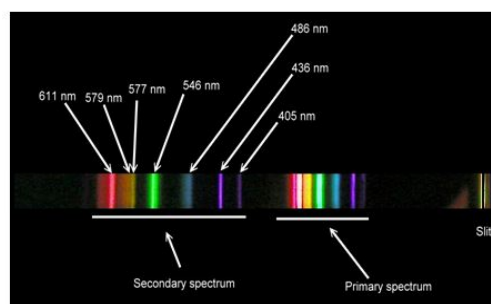


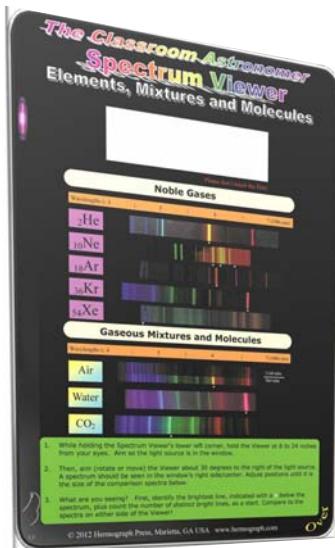
Figure 4. Emission lines usable for calibrations.



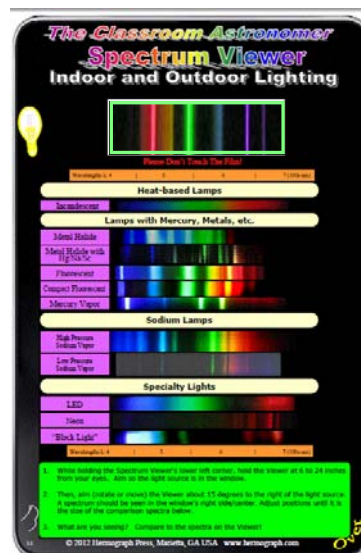
Access *The Classroom Astronomer* worksheets, URLs and other resources from articles online. Get large clear copies for use in your classroom at

<http://classroomastronomer.toteachthestars.net/resourcesbyissue.htm>

# The Classroom Astronomer Spectrum Viewers



Two-sided viewer designed by an astronomy teacher for ease in seeing and identifying element and molecular spectra from gas tubes



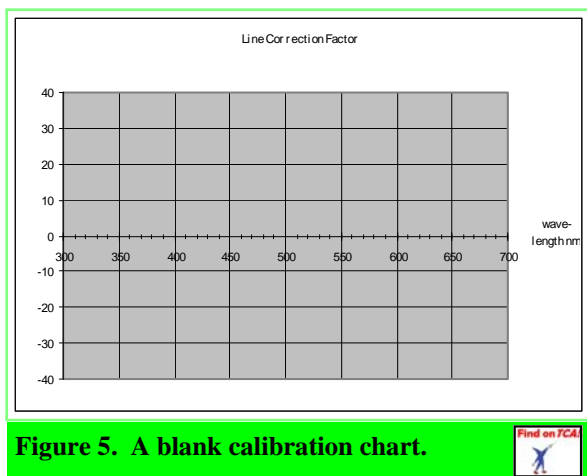
*Elements, Mixtures and Molecules    Indoor and Outdoor Lighting*

**\$9.50 each, Classroom Sets of 10: \$85, 30: \$228, 40: \$285**

Web: [www.hermograph.com/spectrumviewers](http://www.hermograph.com/spectrumviewers)

Toll Free 1-866-HERMOGRAPH Ph: 1-404-702-8147

measure the lines of Mercury and Helium (see Figure 4 on page 9). Together they have around 10-12 lines of



**Figure 5. A blank calibration chart.**



known wavelengths. Make a graph of differences (observed - known) on the Y axis and observed wave-length on the X axis (Figure 5). For most spectroscopes, the differences will be usually small or non-existent for violet through yellow or orange. If your scale is not placed properly in its holder, then you will get fairly constant, non-zero differences. In either case, in the red zone you'll start getting much larger sets of differences because of the discordance between the linear scale and non-linear diffraction process.

Once you have the graph, a student can then measure any line of any emission or absorption spectrum, and subtract the difference for that observed wavelength and get the real wavelength.

Note to lower grade teachers. There are quite a few textbooks that show the spectrum with a scale along the bottom for wavelengths. As a backup to a lack of

spectroscopes, you can do a proportions/ratio exercise and get similar results. **TCA**

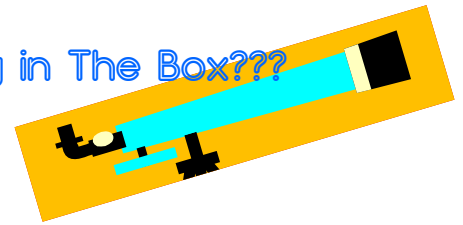
*All photos from the author.*



## Oh, Nooo! What's That Thing in The Box???

### Overcoming Telephobia

- Chuck Ruehle



In 2010 and 2011 I taught astronomy to students in remote locations in Tanzania, East Africa. When I describe the Telescopes to Tanzania program I founded, I often repeat a quote from Oscar Wilde who once said, “Ordinary riches can be stolen, real riches cannot.” I often add, “Something magical, mystical, even spiritual occurs the first time the photons in the eyepiece strike your eye. They stay with you throughout your life — residing in your soul.”

The problem is....even here in the United States, I sometimes —often!—encounter teachers who are interested in astronomy, yet they are reluctant to teach the subject because they have a fear of using a telescope. Readers may also know some colleagues who also have Telephobia. Perhaps *you* are one of those persons. Rest easy. You are not alone. Help is here. My Top Ten List of the most common reasons given not to use a telescope is below – along with some ideas that might help you and more people step up to an eyepiece to catch some photons. Telephobia can be overcome!

**The manual is lost:** Unlike students who lose their homework and have to re-do it, the internet provides a simple solution. Try the manufacturer’s website or go to [retrevo.com](http://retrevo.com). Look for the manual by brand name and model. I have found manuals for scopes that are 25 years old using this technique.



**It’s a donated scope and we don’t know how to use it:** Check with a local community college for instructors who teach science classes and ask for assistance. Or talk to someone from a local Astronomy Club. With over 200 member societies, just check under the “Member Societies” link on the Astronomical League’s website at <http://www.astroleague.org/> or call a regional leader listed under the “Region Information” link.

**We can’t align our “Go To” scope, so we can’t find the objects we are looking for:** First, do all the usual technological checking, i.e.: power supply, fresh batteries, plug and cable connections, ask customer support for help. Some low cost scopes with these features are often over-rated in their ability to stay aligned or may need additional fine tuning. Failing all that, if the optics are reliable, just use the scope and disable, or disassemble, the Go To features. Most scopes allow manual operation without all the complications that power-driven scopes may present.



**I get lost in the night sky and can’t find the objects I’m looking for:** For starters, begin with modest goals. Learn the night sky by observing naked eye or with binoculars, and then use a telescope to look for easy-to-find objects to build confidence before moving on to deep-sky targets. In addition to computer planetarium programs and books that offer sky charts, there are several on-line resources that are simple to use. Uncle Al’s sky wheel is found at <http://www.handsonuniverse.org/activities/uncleal/>. A free monthly sky map is available at <http://www.skymaps.com/>. Both of these are also excellent classroom resources for students too.

**The math and science needed to do astronomy is too scary:** Very little math is needed to observe successfully. You may want to understand what the focal length of your telescope is so you can determine the magnification provided by each of your eyepieces. Folks will likely want to know what the size of your primary optics are (objective lens or mirror). You should know what a light-year measures and what an astronomical unit is to help answer questions like “How far away is Jupiter, the Moon, or the Andromeda Galaxy?” Ultimately, I’d encourage you to just enjoy the beauty and wonder of the night sky, and leave the math for others to explain.

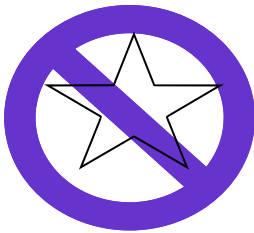




**We don't have a budget for expensive equipment like telescopes:** There are some very useful observing tools available for very modest cost. The Galileoscope can be found at <http://galileoscope.org>. Used with a simple camera tripod (ask for donated ones lying in the back of closets), this easy-to-assemble kit enables you to teach optics and demonstrate how a telescope works while providing good optics at a low price. Before you purchase a telescope at a local outlet, check out The First Telescope Buyers Guide found at <http://wisconsinastronomy.org/>.



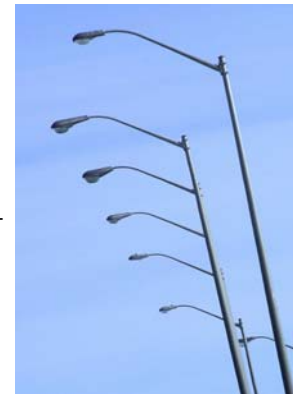
**I worry that the students will break the equipment:** My basic strategy here is to have lots of help when observing. If you are using basic equipment like the Galileoscope, they are very sturdy and stand up to hard use. I typically keep students lined up about 10 feet behind the scope while inviting one student at a time to observe the object. It also helps to keep students busy. Last fall while observing Jupiter in Tanzania with several hundred students we even made up chants in English and Swahili to help us remember the names of those four moons, "All together now -- Io, Europa, Ganymede, Callisto!"



**We can't schedule any evening activities for our students:** If it's forbidden or impractical to bring students together at school in the evening you might try giving assignments for observing at home – even lending out basic scopes through the school library. Over the course of a semester a class of students could take turns and work in small groups to complete simple observing assignments. Getting involved in Global Hands-on Universe at [www.handsonunivers.org](http://www.handsonunivers.org) can enable students to use remote telescopes to capture images for study and research.

**We just want to use a telescope during the day when students are here:** For an article on using Galileoscopes to duplicate Galileo's solar observations, see the Fall 2011 issue #9 of *The Classroom Astronomer*. You can also focus on observing the Sun with a Solarscope available from <http://www.solarscope.com/us/index.us.html> or from Edmund Scientifics at: <http://www.scientificsonline.com/>. This tool allows you to observe sunspots, transits of Mercury or Venus, and eclipses. The teaching guide helps you do a variety of measurements and calculations Earth's rotation speed, latitude, the duration of the day, and other observations.

**We don't have dark skies, there is too much light pollution:** Try observing objects that often penetrate even the brightest night sky. You can view the Moon and teach about its phases, the tides, etc. Study the planets: Jupiter, Venus, and Mars. Teach about light pollution and participate in world-wide star counts. Information about the Dark Sky Rangers and Globe At Night projects is found at <http://www.site.galileoteachers.org/>. You'll find a variety of ideas and activities for teaching, and learn about the Galileo Teacher Training Program here. **TCA**



*Chuck Ruehle is a member of the Racine Astronomical Society, and a retired Evangelical Lutheran Church in America (ELCA) pastor. Google "Telescopes to Tanzania" for more information on that project, or search for Chuck Ruehle at <http://www.astronomerswithoutborders.org/>. Reach him at [Chuck.Ruehle@yahoo.com](mailto:Chuck.Ruehle@yahoo.com).*

**Write for THE CLASSROOM ASTRONOMER!**

**Submit your ideas to**

[editor@toteachthestars.net](mailto:editor@toteachthestars.net)

# SUMMER PLANNING CALENDAR

## PLANETS

If you want to include planets in your curriculum, it is best to do so when they are easily visible. This table tells you whenever a planet is visible **at least 45 minutes after sunset** (**blue**) or **before sunrise** (**green**). Black = most of the night hours, white = not visible.

<u>Planet</u>	<u>July</u>	<u>August</u>	<u>September</u>
<b><i>Mercury</i></b>	Moderate morning show begins 18th. Max distance from sun, 30th...	...max brightness 13th, in solar glare after 17th.	Hard to see in dusk-light, from 15th thru October.
<b><i>Venus</i></b>	Low in the western twilight glow.	—————>	Sets after twilight ends after 6th.
<b><i>Mars</i></b>	Rises before dawn > 22nd, gaining space between it and Sun.	In pre-dawn skies.	—————>
<b><i>Jupiter</i></b>	Rapidly emerges from solar glare, rising >45 min before sunrise, 2nd; > dawn, 22nd.	Pre-dawn riser!	Rises middle of the night (1AM DST) on 16th.
<b><i>Saturn</i></b>	Sets middle of the night (1AM DST), 15th; midnight, 31st.	Still a good evening show.	Sets end of evening twilight, 29th.

## CLASSROOM MOONS

Moon phases are a frequent observing assignment. Do you Moon-gaze during evenings or mornings? Here's when the Moon is prime for early evening or school hour observing!

**Evening Moons**  
(Waxing  
Crescent to  
11PM setting)



**July 9—15**  
**August 8—14**  
**September 7—12**

**Full Moons**



**July 22**  
**August 20**  
**September 19**

**School Hour  
Moons (Waning  
Gibbous to Wan-  
ing Crescent)**



**July 1—2, 25—31**  
**August 23—29**  
**September 21—29**



# SUMMER PLANNING CALENDAR

## SPECIAL EVENTS

**July 5 — Earth is at aphelion.** Farthest from the Sun, sure is hot today.....

**July 9 — Saturn stops retrograding, moves eastward now.**

**August 11-12 — Perseids meteor shower,** peaks noon EDT on the 12th in Atlanta so best times are the night before and night after this noon.

**August 17-18 — Venus marks the Autumnal Equinox** position in the sky! Just over a month from today....

**September 22 — ...the Sun will stand here instead!** This is the date of the Autumnal Equinox. 4:44PM EDT in Atlanta.

### ✿ BORDER CROSSINGS ✿

It is important to get the right dates and constellations when you talk about the zodiac. The Sun,  $1/2^\circ$  in size, takes about half a day to go from one zodiac constellation to another; we presume you to be the latter constellation if you are born on a crossing date. Here are the crossing dates (and ecliptic longitudes):

**July 20** Gemini/Cancer ( $118^\circ$ ) **August 11** Cancer/Leo ( $138^\circ$ ) **September 16** Leo/Virgo ( $173^\circ$ )

## CLOSE ENCOUNTERS

It's always easier to find things in groups, so here are the best, closest meetings (conjunctions) of planets with planets or the Moon! Use the rule of thumb (literally); the one-half-degree-diameter Moon is hidden by your thumb; one degree is about two Full Moons, or two thumbs, in size.

**July 16 — First Quarter Moon  $0.3^\circ$  from Spica.**

**July 17 — Saturn  $3^\circ$  from Moon in the evening sky.**

**July 22 — Mars and Jupiter  $0.8^\circ$  apart in the dawn, rising at dawn's start, too! Venus  $1.2^\circ$  from Regulus in the evening twilight.**

**September 5 — Venus  $1.8^\circ$  North of Spica.**

**September 8 — Moon  $0.4^\circ$  South of Venus. Spica  $0.8^\circ$  South of Moon.**

**September 9 — Saturn  $2^\circ$  North of Moon.**

**September 20 — Venus  $4^\circ$  South of Saturn.**



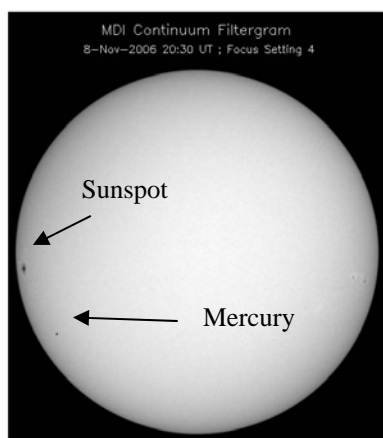
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Discussions, offers, article info  
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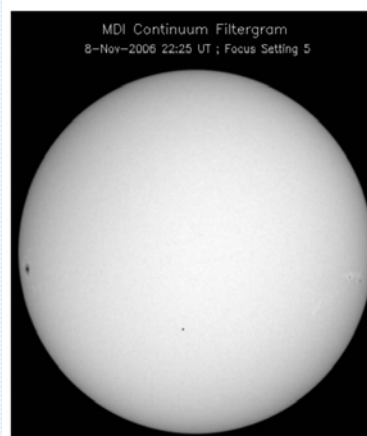
Updates and upcoming articles to *The Classroom Astronomer*  
Workshop announcements



## A Transit of Mercury Lab



This is an excerpt from a pair of laboratory exercises developed for college/high school and upper elementary students on the Transit of Mercury of 2006. Five photos are involved, here we see the first, middle and last of the time series. The grid at lower right is used as a master for a transparent overlay to be placed over each photograph. Drawn on the overlay would be the positions of Mercury, seen as a little dot in different positions on these



photographs.

The Sun's diameter is used as the scale for these photographs. The photographs were taken by the Sun-facing SOHO satellite; the first and last photos are 4 hours and 58 minutes apart. While the photographs look straight forward, in fact, times and distances measured from them need corrections due to the Earth's revolving around the Sun while SOHO was observing Mercury. (A) In this excerpt, accept that your measured transit path length over the Sun's face has to be divided by 0.83 to get the length actually viewed on the Earth. (B) We'd like to know also how far around in its orbit Mercury went, the orbital angular distance; to get that, multiply your angular measurement of the arc of the transit across the Sun (which was  $0.538^\circ$  itself) by 2.10.

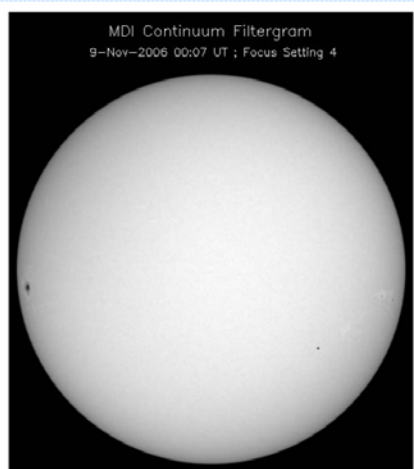
The expected outcome, at the secondary level, was the orbital speed of Mercury and a comparison to expectations due to Kepler's Second Law, that states that objects move faster when they are at the closer points of its orbit (perihelion) than when at the farther point (aphelion).

On that 2006 date, Mercury was 9.96 arc-seconds ( $9.96''$ ) in size. Mercury was 0.675 AU from Earth and the Sun was 0.997 AU from us, thus Mercury was 0.322 AU from the Sun whereas on average it is at 0.387 AU. Conversion:  $1 \text{ AU} = 1.496 \times 10^8 \text{ km}$ . Mercury moves  $5.8^\circ$  per day in orbital motion around the Sun. In all the following, watch your units, convert as needed!

(C) The planet's orbital velocity  $V$  should be equal to the planet's distance from the Sun times the angular orbital velocity on that day (the apparent track length (B) you measured above, with the corrections, finally, converted to radians), divided by the time between the first and last photos. Done correctly, one can determine if Mercury was near its aphelion, perihelion, or in between.

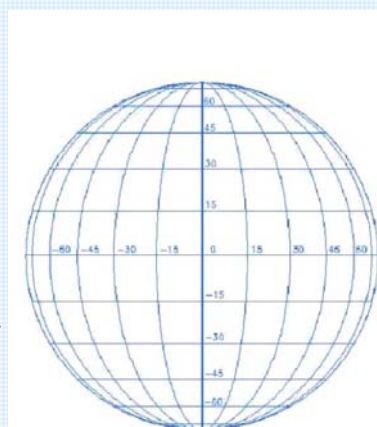
In the elementary version, students plot the transit, but only do comparisons of sunspot, Mercury, Sun and Moon sizes (the latter with a supplied photograph).

The sunspot visible on the left side is measured as a proportion of the Sun's diameter, converted by ratio to kilometers.



Find the exercises at <http://mathcs.emory.edu/~mic/kbenson/mercury/professorpak.pdf>; the elementary one at <http://mathcs.emory.edu/~mic/kbenson/mercury/teacherpak.pdf>. **TCA**

*Katherine Benson created these labs while working at Agnes Scott College, Decatur, GA. Email her at [bensonphysics@gmail.com](mailto:bensonphysics@gmail.com).*



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# Astronomical Techniques - A Potpourri of Ideas

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## Recent Classroom Ideas

This past semester offered a chance to try a number of ideas out on a college astronomy class, a basic course of 3 one-hour lectures and a two-hour lab section (two sections, to accommodate all the students), strictly for non-science majors. There was some traditional lecture and a whole lot of student-centered activities, sometimes in the class and sometimes as out-of-class activity. One thing that sets this class different than others I have done is that it was divided into a set of units based upon “Grand Questions.” There were ultimately five such questions: How Does Science Work?, How Do We Know Where Things Are In The Sky?, What Things In Space Actually Affect Us On Earth?, Where Do We Come From?, and Where Can We Go From Here?.

Below are some of the topics and strategies that were done in the class which you might find useful in your class, be it college, high-school, or other .

### Class Projects

In the past, my students have often had some kind of longer-term project or activity to do—say, observe something with a remote telescope, or do some group research and presentations. This semester I took an idea from a prior course instructor and had them do projects but, this time, I specified that it had to be related to their majors. The class was populated with a variety of non-science majors, with several majors predominating, notably Political Science, Psychology, and International Studies. As one key goal of the course was to show that astronomy was not isolated from our daily lives or cultures, this was a way to have students meet this goal. The results were quite interesting. Here are some capsule descriptions of the better projects:

A video survey of campus students expressing views on three questions, such as should all nations be allowed to exploit and explore space, or should weapons be allowed to be in space? Included interludes explaining science concepts illustrated with stop action filming!

Piaget and Astronomy Activities for Kids

Foamhenge (a recreation of the Pipehenge educational product)

A simulation of a Senate debate on light pollution, using a real bill as the object under discussion.

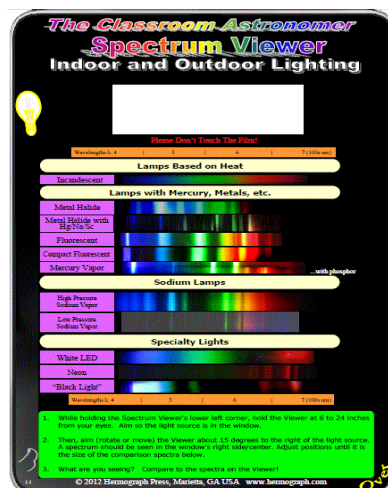
A reading of Galileo’s Journal (using his quotes and text to simulate he might have said, written as a diary written over his life, illustrated with appropriate slides, and very dramatically read).

Talks on commercial and military uses of space, and discussions on the five Space Treaties.

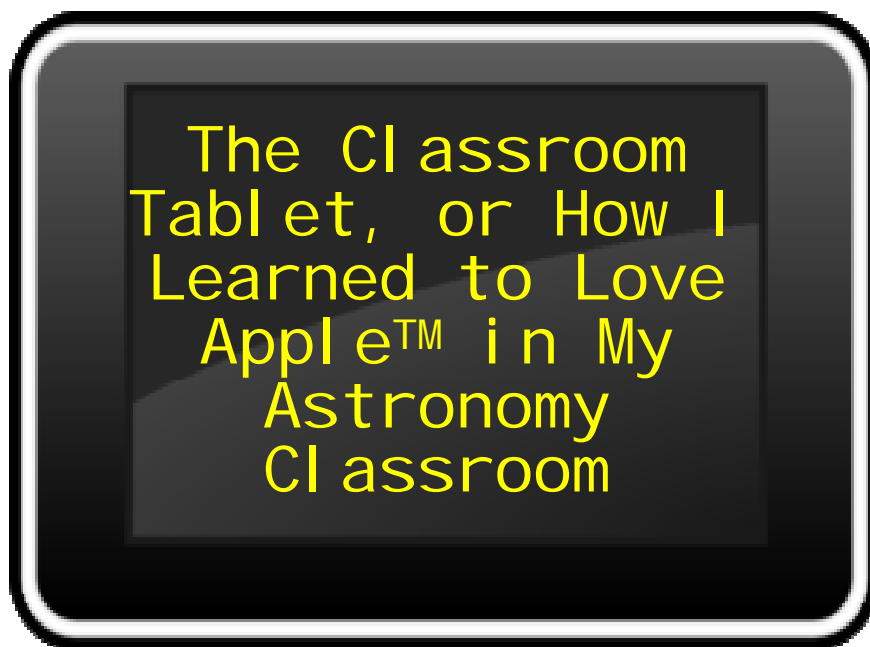
A video interview with a Martian upset with what it perceives as an invasion of Mars, with laser weapons and more (our various Mars missions).

### Light Pollution Survey And color changes

Using *The Classroom Astronomer* Indoor and Outdoor Lighting Spectrum Viewers, students over a weekend had to go someplace and do a survey of that area’s lighting. Most did their survey on some part of campus but some went into the surrounding metropolitan area and one did a survey out of state. Using data on the Lighting Notes and the obverse of the Viewer card listing energy and cost efficiency values, students counted all the lights seen, identified what kinds of lights they were (high-pressure sodium, etc.) and used the data to grade the area for cost and energy usage. The campus, which had recently installed LED lighting, had many areas with high B and A grades (in the traditional 80’s, 90’s grade scaling) while around the city, almost every place had an F grade! It was interesting to see also that a place could be energy-efficient but not cost-efficient, or vice versa; it isn’t always B and B, or F and F. **TEA**







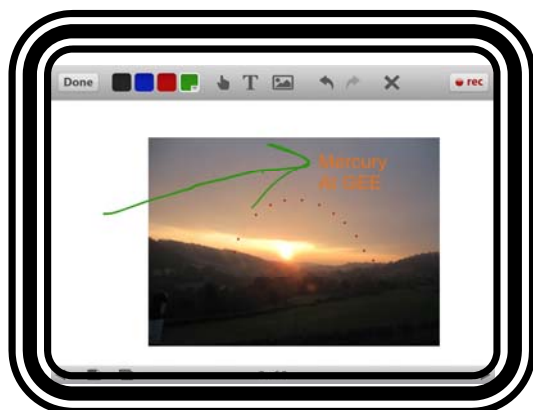
When I taught high school physics, my class was the most fun of all the science classes because I had a Smart Board running off my own laptop and the school's LCD projector. I could project websites with Java simulations, or run programs, where students could touch the board and drag things around in exercises. PowerPoints moved with a double tap of the fingers.

Now I teach occasionally at a college where the classrooms have computers, ceiling mounted LCDs, but I still have to use my own laptop because nothing can be stored overnight on any computer there and there is no Smart

Board. I've missed that interactivity.

Then I won an iPad 3 as a conference door prize.

The iPad is smaller and lighter than my laptop and I can walk around with it, especially since mine came equipped with a cover that had a built-in swivel handle by which I can hold the iPad in any position as I move. My first purchase was a connector to tap into the laptop line to the LCD projector. But, as I've gotten more Apple-savvy, I've been trying to find ways to use the iPad in classroom situations more and more. Yes, there are many Apps out there that are informative *for* the teacher. What time is local sunset? There's an app for that. Planetarium sky charts? Check. But these are little different than what I can do with my laptop. What can I do that is different, *as* a teacher? The first good difference I've found is the amount of in-class graphics demonstrations, somewhat akin to what I could do on the Smart Board.



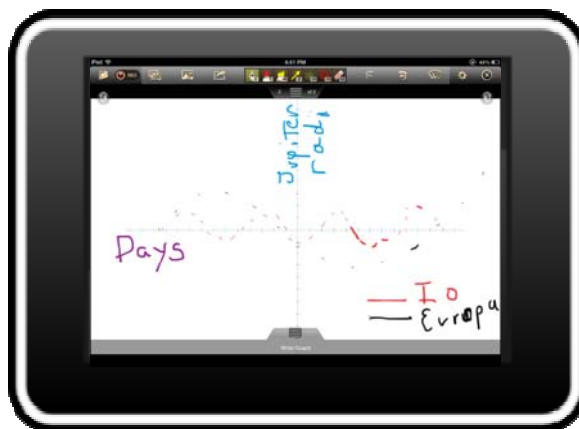
① *Educreations*, a whiteboard app.

**Educreations** ① I was talking about orbits and suddenly, on the white background on-screen, there appeared an ellipse, in color, growing as my finger invisibly made the curves...and then another one further out showing the same eccentricity, just with a larger diameter. There was an audible gasp out of my students.

*Educreation* "slides" can contain text, photos and

### That's Smart!

I found two different free "whiteboard" apps that allow me one of the Smart Board's fun attributes, being able to draw in different colors. Using



② *Doceri*, another whiteboard app.

images, and you can record a brief lesson in real time and with sound. However, you have only color control of the lines you make. A second whiteboard program, **Doceri**, ② in its free version, has much more in the graphics department—colors, opacity, make squares and circles, different line thicknesses, a neat collection of backgrounds including all kinds of graph styles—but no text input except what you can do by finger. It, too, has recording capabilities. Choose the program you want for your purposes. *Doceri* has a non-free upgrade that includes some kind of remote projection aspect; I haven't tried that yet.



④ *Planets* is a very versatile app. (A) above shows the planets as they are now or any time, from any angle and distance. (B and C, below). Show any planet's surface from Mercury to Neptune, from pole to equator. (D, right) Yes, you can see what's up, in any wavelength of light, including visible and hydrogen-alpha radiation!

Then, bring up another free app, **Planets**. ④ You can look at the whole solar system from any angle—in the orbital plane or from above or below, zoom

## The Universe Has (More Than) Three Dimensions

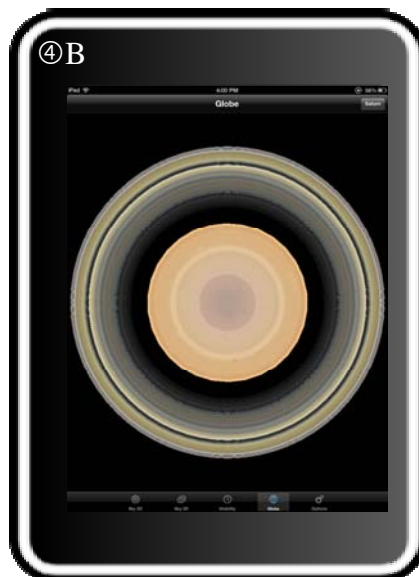
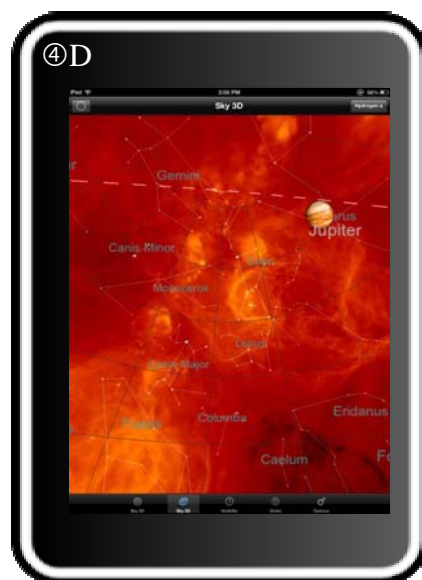
I found something useful for Moon phases. First, I found a free app called

### Moon Globe ③

Among its features—you can control the illumination over the face of the Moon by a slider. Run through all the phases smoothly, continuously, from New to Full to New. You can even turn on labels for the seas and craters, a great atlas feature of its own, zoom in, and watch the changing sunlit peaks and crater walls, and shadows. See how Tycho or Copernicus craters look at lunar sunrise, and noon!



③ The slider (upper right) of *Moon Globe* controls phases.



in and out and to any object. From far away you can see how every planet is half lit from the Sun. Close in, center on Earth and advance the time and watch the Moon orbit our planet, always half lit up, but shift perspective to the Earth and view the actual phase we see! It's the perspective shifting that often throws students on paper exercises; here they

can see it in action! Projecting the image shifting live on the screen, movement activated by my not-visible finger, and presto! You have their full attention!

The *Planets* app has two other nice interactive graphical features. First, it does have a planetarium setting in it where you can set the time and location and see what's up. There are better ones available for that purpose but *Planets* does give you an interesting lesson twist. You can change the background behind the stars from photographic visual (see the Milky Way?) to what it would look like in other parts of the electromagnetic spectrum, such as in hydrogen-alpha light or radio or X-ray or microwave and so on! Then click the Globe option. Start with the Earth spinning, the terminator's penumbral shading evident, and the lights of cities. Then tap the button in the upper right to get globes of the Moon or any of the planets out to Neptune. Cooler still, touch the image and you can rotate it to see the world from one pole to the other. This is especially nice for Saturn—there's the hexagonal polar cloud belt and the rings from above (not something we see from Earth!) then watch them disappear when you pass through the ring plane.

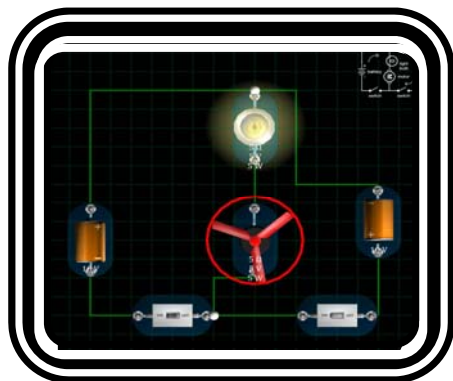
## What's in Your Office?

Now here's a dilemma. If you've been in astronomy teaching for any time you've probably got a hard drive full of PowerPoint files. Uh oh. There is no *Microsoft Office* for iPads. Fortunately, there are numerous programs in the App Store that can read and display the files but you will likely lose some of PowerPoint's media features—no movies or sound embedding or flashing letters or funky slide change dissolves. I am using **QuickOfficeHD** ⑤ and **OfficeHD**. Although both read the PowerPoints, they can't read files I uploaded specifically to one program if I uploaded them to the other program!



⑤ *QuickOfficeHD*, an *Office* clone.

## Physics, Too!

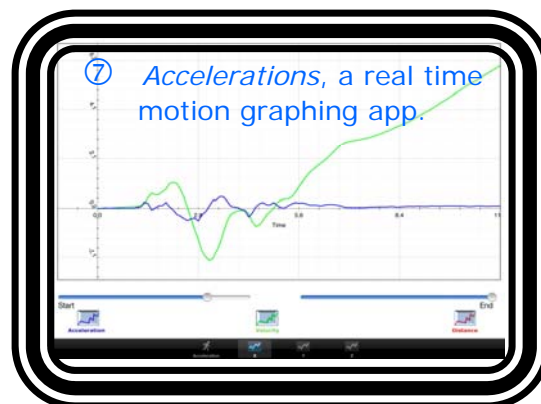


⑥ *Circuits*, a drag-and-connect electrical circuits app.

Many astronomy teachers teach physics, too, and this semester is no exception for me. I've found two good interactive physics apps so far. **VSB Electronics** ⑥ is a

simple, 10-part build-a-circuit app. Drag a switch, battery, resistor, lamp or motor onto the screen and make circuits as simple or complex as you like. Oh, and if you short the circuit, the batteries send out sparks! The

other program is **Acceleration** ⑦. There are internal accelerometers in iPads. *Acceleration* reads them and instantly plots your motion along an X, Y or Z axis, as accelerations, velocities and distances moved! Now if I can figure out how to attach this safely to carts or other objects...

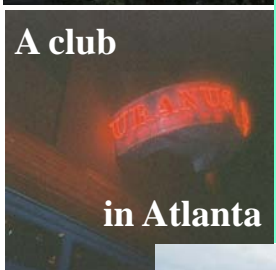
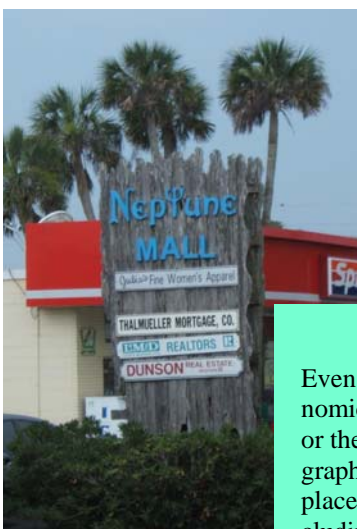


⑦ *Accelerations*, a real time motion graphing app.

From time to time, I will revisit this topic. Have experiences, or recommendations? Email them to [editor@toteachthestars.net](mailto:editor@toteachthestars.net), or comment on *The Classroom Astronomer* Facebook page. —LK **TCA**



## Photons Focused On: Solar System Names



We love astronomy!

Even people who don't know astronomy like to use astronomical names in their businesses, for the business name or the products. Here we have a collection of photographs taken over the years of products, businesses and places that have the names of Solar System objects, including ol' Sol itself and the two dwarf planets most people might know! We've put them in order, from the Sun outwards, going clockwise around the page.

Future columns will look at other categorizations of astronomical names in non-astronomical situations. If you have photos or grouping ideas you'd like to share, please send them to [editor@toteachthestars.net](mailto:editor@toteachthestars.net). TCA



OK, so they are a little behind on their world shapes...

You  
KNOW  
what to  
put in  
here for  
Saturn,  
right??





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