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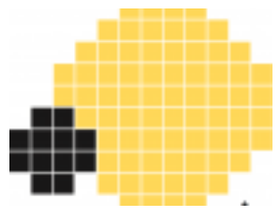
SCIENCE & MATH

Activity: Pixel Count

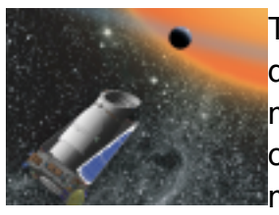
LAST_UPDATED2

Chuck

Plot the amount of light detected by a spacecraft as it observes a planet transiting a star.

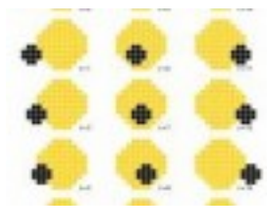


Background: There are several ways to find new planets. First, scientists can sometimes measure the wobble of the parent star caused by the gravity of the hidden offspring planet. Second, they can detect a Doppler shifting of the star's light spectrum as the orbiting planet repeatedly moves toward us, then away. Third, they can look for dips in brightness that reveal planets blocking out a little light as the planets orbit the star within our plane.

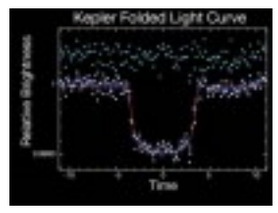


The **Kepler spacecraft** is monitoring over 150,000 stars simultaneously as it looks for planets around distant stars. For comparison, imagine looking down from a skyscraper at 150,000 streetlights that are miles away and you hope to see some gnats flying in front of a few lights. If the insect passes in front of the streetlight along your line of sight, the amount of light you see will dip by a minute amount. It may be too little for your eyes to notice, but the spacecraft is capable of discerning such small dips in brightness.

In this activity, the light from a star covers several pixels on a simulated computer chip. From afar, the star would appear as a mere point of light, but the closer you get the more you can see and count distinct pixels. For simplicity, students will count the number of pixels that reach the sensor for the duration of a transit. A recurring, periodic dip in brightness suggests a planet is orbiting the host star, whereas a random dip in brightness may indicate any object, such as a nearby asteroid in our own solar system, is intersecting the light path between the star and the spacecraft.



To Do: Print or display the **15 snapshots**, left, of a transit. On graph paper, plot the numbers of yellow squares (y-axis) per unit of time (x-axis). You may want to begin with multiple t=0 pixel counts to show the normal state of the scene with no transit, from which the curve can begin. The units of time are not defined for this activity, but a transit may last for several hours. Compare the graph derived by the students with actual data from a transit, right. To speed up the activity in a class, assign each kid the t=0 time frame just to make sure they are all on the same track. Then have the kids choose a partner to count the lone second snapshot you designate for them.



Read more: Activity: Pixel Count

Links: Science & Math

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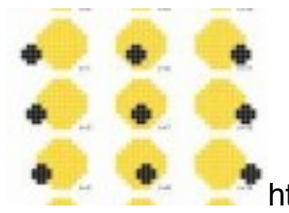
http://sunearthday.nasa.gov/2012/articles/ttt_75.php
Mathematical Problems Featuring Transit Applications, by Dr. Sten Odenwald. Transit Math book from NASA opens with dozens of math problems and answers related to eclipses, transits, and occultations, with an emphasis on transits of Venus through the centuries. Problems align with AAAS Project: 2061 Benchmarks as detailed in a Mathematics Topic Matrix. The PDF document includes summaries of the historic aspects of the transit and a diverse collection of modern images and historic images alike. Stated emphasis for Transit Introduction is on grades 3-8, while Transit Math challenges grades 5-12. "The problems were created to be authentic glimpses of modern science and engineering issues, often involving actual research data...The problems were designed to be 'one-pagers' with a detailed Answer Key as a second page."

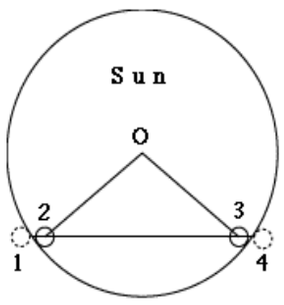
docs/MathPuzzler01.pdf
Six introductory math puzzlers about the frequency of transits, how far Venus is from earth, and the distance from earth to the sun (Astronomical Unit); from Dr. Sten Odenwald, NASA.

http://transitofvenus.nl/wp/2012/02/16/pattern-on-a-paper-plate/
Hands-on activity that illustrates and explains the frequency of transits of Venus using simple paper plates. Now available as PDF file with illustrations, improved from original posting at http://analyzer.depaul.edu/paperplate/Transit%20of%20Venus/transit_frequency.htm.



http://transitofvenus.nl/wp/2011/11/08/classroom-activities/
Free workbook (http://www.transitofvenus.nl/files/TransitOfVenus.pdf) from Steven van Roode addresses the frequency of the transit of Venus, angular measurements, parallax measurements to establish distances, and finding the physical properties of exoplanets from light curves. Also available as hard copy.

education/science-math/316-activity-pixel-count
Pixel Count Activity is modification from Steven van Roode's workbook in which student plots the decrease in light received from a star that has a planet transiting it.

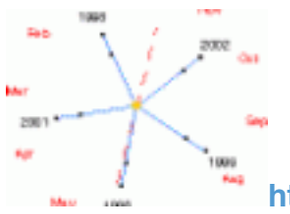


http://www-istp.gsfc.nasa.gov/stargaze/Svenus1.htm
The Transit of Venus --Halley's Method of Deriving the Astronomical Unit (AU); from Dr. David P. Stern.

http://www.astro.uni-bonn.de/~dfischer/skyreports/2004/venus.html
The Astronomical Unit from differential astrometry of the 2004 Transit of Venus? by Daniel Fischer. "Based on a handful of medium-quality photographs of the full solar disk taken during the 2004 transit of Venus, a first attempt to derive the AU by relative astrometry to two sunspots in AR 627 is made."

http://homepage.ntlworld.com/magavelda/ds/venus/ven_ch1A.htm
A tutorial on the transit of Venus as a technique for measuring solar parallax and quantifying the Astronomical Unit; excerpts with illustrations from the book "The Transit of Venus & the Quest for the Solar Parallax" by David Sellers.

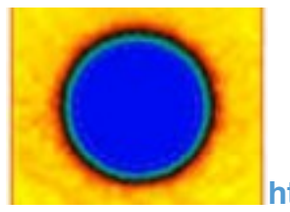
SVR...
Measure the distance to the sun by knowing only your location (lat/long) and the time(s) of internal contact. That is, "compute the mean equatorial solar parallax online from your own and others' observations of the 2004 transit of Venus, employing *either* Halley's or Delisle's method." This is the easiest method for casual observers to quantify the distance to the sun from their own data..



http://www.astronomy.org.gg/venustransitsb.htm
An explanation of the frequency of Venus transits by Peter M. Langford.

http://eclipse.astroinfo.org/transit/venus/project2004/pub/Blatter.etal.eng.200306.pdf
Venustransit 2004: Calculation of the Solar Parallax from Observations by Heinz Blatter. Detailed math "gives an overview of the geometry and temporal patterns of transits, a rough estimate of the solar parallax and the corresponding error estimate. The possible and necessary corrections due to the rotation of the Earth, the eccentricities of the orbits of Venus and Earth and the inclination of the orbit of Venus are given as well."

http://www.phy6.org/stargaze/Svenus2.htm
"Approximate calculation of the AU based on the June 8 transit of Venus, meant for the level of high school or beginning college and uses only algebra and simple trigonometry. It only relies on simulated data--specifically, predicted times of 2nd and 3rd contact for Cairo and Durban;" from David P. Stern.



http://nicmosis.as.arizona.edu:8000/POSTERS/TOM1999.jpg
Poster on the 1999 transit of Mercury "definitively solves the problem of the black-drop effect that plagued past transits of Venus;" by Jay Pasachoff, Glenn Schneider and Leon Golub; from the American Astronomical Society's Division of Planetary Science meeting in 2001.

http://www.williams.edu/astronomy/eclipse/transits/index.htm
Jay Pasachoff's site links to transit of Venus interests.

http://www.transitsearch.org/
An observing program whose purpose is "to coordinate and direct a cooperative observational effort which will allow experienced amateur astronomers and small college observatories to discover transiting extrasolar planets." To observe transiting planets around distant stars, you need a telescope with an accurate clock drive, a CCD camera, and appropriate computer software. Observers who obtain photometry of known transiting planets can submit their light curves. The transitsearch.org site currently functions primarily as an ephemeris information service.

http://oklo.org/
The Systemic Weblog, written by **Greg Laughlin**, reports recent developments in the field of extrasolar planets, with a particular focus on observational and theoretical astronomical research work. Tutorials show how to use the **Systemic Console**, a program that "uses an intuitive graphical interface to analyze data in order to detect and characterize planets."

http://home.att.net/~o.caimi/Venus.html
"The Transit of Venus" by David Murray; from December 8, 1874, *Scribner's*.
"Astronomy, The Transit of Venus" by Gillet and Rolfe, 1882.

SVR...
Detailed math excerpted from Robert Stawell Ball's *Treatise on Spherical Astronomy*, 1908, addresses the conditions under which a transit takes place; variations of the sun's path as seen from different points on the earth; and both Halley's and De Lisle's methods for applying a transit of Venus to determine the Astronomical Unit (A.U.)

http://sunearth.gsfc.nasa.gov/eclipse/transit/catalog/Visible.html
Formulas and data to show how to calculate whether the transit is visible from any given location; from Fred Espenak.

http://libnova.sourceforge.net/group__venus.html
Calculation engines for C / C++ programmers, astronomers and anyone else interested in calculating positions of astronomical objects; from free software *libnova*, a general purpose, double precision, astronomical calculation library.

http://chandra.harvard.edu/photo/cycle1/venus/index.html
Venus in X-ray; images by Chandra observatory.

http://nssdc.gsfc.nasa.gov/planetary/planets/venuspage.html
Venus page from NSSDC (National Space Science Data Center); includes missions, data on CD ROM, and links.

http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-venus.html
Photo gallery of Venus; from NSSDC.

http://nssdc.gsfc.nasa.gov/planetary/magellan.html
Magellan mission to Venus.

http://www.seds.org/pub/info/newsletters/ejasa/1993/jasa9302.txt
http://www.seds.org/pub/info/newsletters/ejasa/1993/jasa9303.txt
http://www.seds.org/pub/info/newsletters/ejasa/1993/jasa9304.txt
Three-part series on the Soviet and American exploration of Venus, appearing in the electronic Journal of the

Astronomical Society of the Atlantic; by Larry Klaes.

http://www.glenn.freehomepage.com/writings/Pentacle/
"Pi, Phi, and the Pentacle" features the five-point pattern derived from the aligning orbits of Venus and earth; from Glenn R. Smith.

http://www.transit-of-venus.org.uk/science.htm
Using parallax to measure distance; from University of Central Lancashire.

http://video.google.com/videoplay?docid=-7601411332170624 03&q=transit+venus
NASA Connect offers lessons and exercises on scaling the solar system.

http://www.oca.eu/Mignard/Transits/Data/venus_contact.pdf
*The Solar parallax with the transit of Venus "*shows how one can derive the timing of the four contacts of Venus with the sun disk as a function of the location of the observer and of the solar parallax with a relatively simple approximate formula whose accuracy is sufficient to process the observations of a network of observers. Two models are discussed." From F. Mignard.

http://www.math.nus.edu.sg/aslaksen/gem-projects/hm/0506-1-16-Parallax.pdf
Parralax math, by gamers.

http://www.compstar-esf.org/index.php?section=news&nid=35
Compact Star conference to be held in Tahiti - June 4-8, 2012, Arue (Tahiti), French Polynesia

https://venustex.oca.eu/foswiki
Venus Twilight Experiment writes: "During ingress and egress a bright and thin luminous arc (the "aureole") is observable, appearing around the circumference of Venus' disk which is partially outside the solar limb...Farther away from the Sun, the aureole - due to light refraction - disappears and Venus shines from the light diffused by droplets dispersed above its thick cloud deck.The Venus Twilight Experiment is establishing an international collaboration for deploying specialized instruments in the transit visibility area to get multi-wavelength data...Our final aims are a better characterization of these twilight phenomena and - in turn - an improved undestarding of the atmosphere of Venus, jointly with the observations obtained by Venus Express, the probe now orbiting the planet."

http://site.uit.no/venus2012/
Venus Transit Conference Tromsø 2012, a conference focusing on the history of the transits of Venus, 2-3 June 2012.

Links: Planet Venus

JANUARY_SHORT 06 | 09:54 **Chuck**

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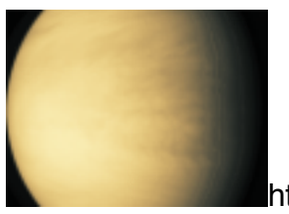
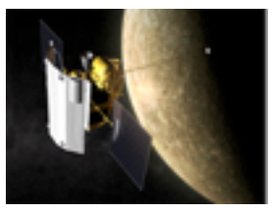

http://solarsystem.nasa.gov/planets/profile.cfm?Object=Venus
NASA's Solar System Exploration site features an overview, details a gallery, facts and figures, and education links for the planet Venus.

docs/venus_earth_sun_fact 2.pdf
Venus-Earth-Sun Fact Sheets in US and Metric Units

http://www.solarviews.com/cap/index/venus1.html
Collection of images of Venus, including transit photographs and spacecraft images; from SolarViews.


http://www.nasa.gov/mission_pages/messenger/main/index.html
NASA Messenger spacecraft to become the first to orbit and study Venus, with abundant related resources from NASA.


http://www.nasa.gov/multimedia/imagegallery/image_feature_1836.html

Mosaic of radar images of Venus. Image and description courtesy of NASA.

Rare Alignment

LAST_UPDATED2

A transit of Venus occurs when Venus passes directly between the sun and earth. This alignment is rare, coming in pairs that are eight years apart but separated by over a century. The last transit of Venus was a thrilling sight in 2004. After June 2012, the next event occurs in 2117.

From the FAQ "Why is a transit of Venus so rare?":

Transits of Venus have a strange pattern of frequency. A transit will not have happened for about 121 ½ years (prior to 2004, the last one was 1882). Then there will be one transit (such as the one in 2004) followed by another transit of Venus eight years later (in the year 2012). Then there will be a span of about 105 ½ years before the next pair of transits occur, again separated by eight years. Then the pattern repeats (121 ½ , 8, 105 ½ , 8).

Transit of Venus pairs since the invention of the telescope:

- 1631 (not witnessed) & 1639
- 1761 & 1769
- 1874 & 1882
- 2004 & 2012

If Venus and the earth orbited the sun in the same plane as the sun, transits would happen frequently. However, the orbit of Venus is inclined to the orbit of earth, so when Venus passes between the sun and the earth every 1.6 years, Venus usually is a little bit above or a little bit below the sun, invisible in the sun's glare.

A similar thing happens with our moon. Every month the moon passes between the sun and the earth, yet we do not see a solar eclipse every month. That's because the moon's orbit is also slightly inclined to earth's orbit, so the new moon is usually a little above or a little below the sun. The transit of Venus is essentially an annular eclipse of the sun by Venus.

See the paper plate activity at **http://transitofvenus.nl/wp/2012/02/16/pattern-on-a-paper-plate/** for a model that shows the transit frequency visually.

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