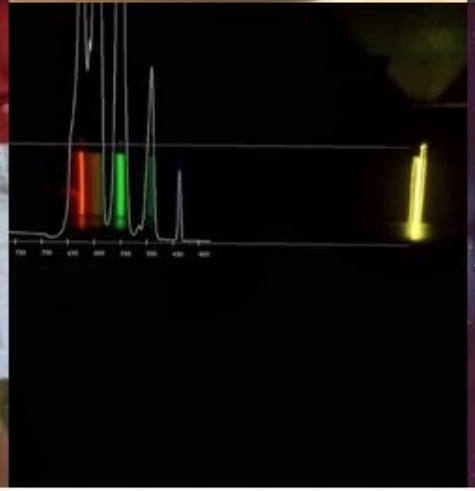
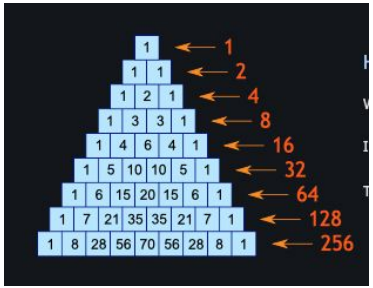
Seattle Creator Studio Citizen Science Workshop Daily Slides _v11

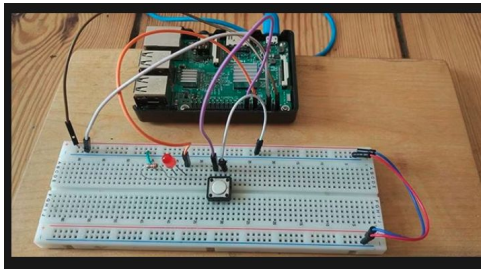
Design Build Explore
Aug 8th - 18th
Chandru Narayan - Teacher

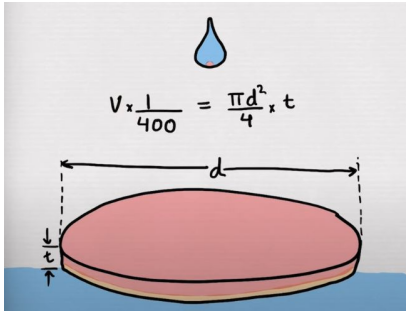


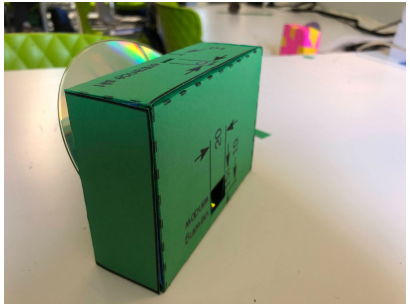



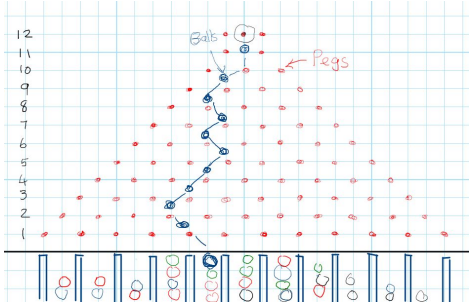

SCS Citizen Science Student Workshop!

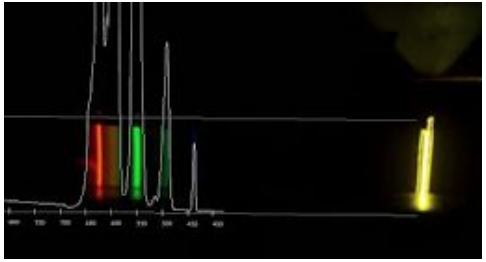






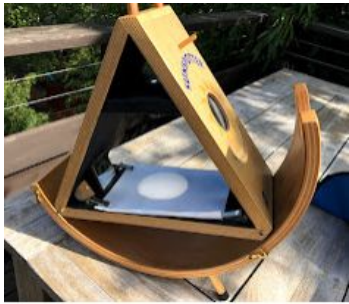


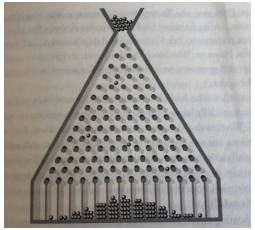


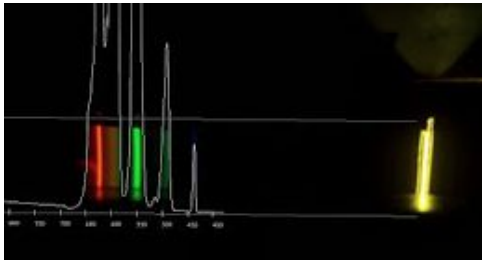


Important Schedule of Events - RSVP for Parents to attend!

Mon Aug 8	Opening Day - 8:30 - 9:00 AM	Course Schedule and Lessons Overview. Announcing important Days for Parents to accompany children - RSVP for attendance today for the 2 events below. Briefly meet Chandru when dropping off kids to pick up schedule
Thu Aug 11	Telescope Night at Ryther 10 - 11:30 PM	RSVP for Star Party observing night at Ryther campus 10-11:30 PM. We will be taking Spectra of Stars and Imaging Galaxies & Nebulae
Thu Aug 18	Citizen Science Expo at SSB - 10:00 - Noon	Parents will RSVP to attend session starting at 10:00 - Noon in the park across from SSB campus to see student experiment demos, Images from Telescopes etc.

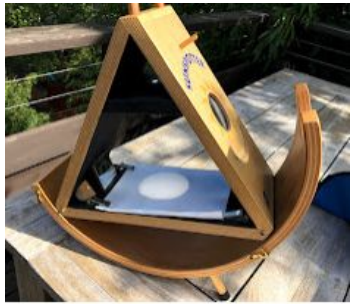


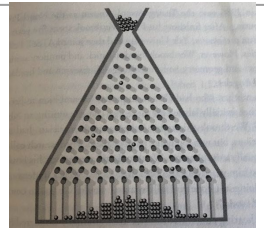


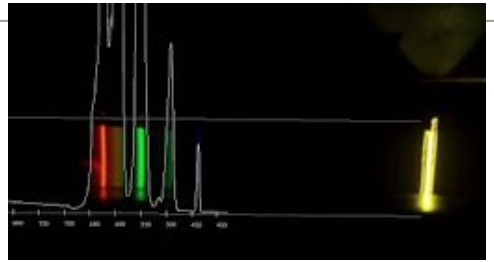


Citizen Science Expo Agenda - Aug 18th

1	Welcome to Citizen Science Expo at SSB **9:50 - 10:00**	Welcome parents and community to expo. Masks are required. We will provide one if you do not have one.
2	Student Experiments & Presentation **10:00 - 11:00**	Students will present their work and demonstrate experiments for about 60 minutes. Students might ask the community questions, so be prepared!
3	Parents & Community will gather in park across SSB for comments, questions **11:00 - 11:30**	Students will take a break in the classroom for some quiet time or can accompany their parent for this portion. Community will gather across park for questions, comments, anecdotes and future opportunities etc.
4	Parents depart and return to pick up their student at the conclusion of the afternoon session **3:00 PM**	Parents depart and return to pick up their student at the conclusion of the afternoon session







~~13~~ 12 Citizen Science Experiments!

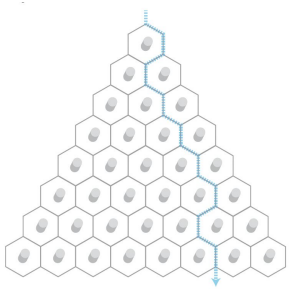
1. Galton Board and Normal Distributions in Nature
2. Fibonacci sequences in Nature - Pine Cones and Sunflowers
3. The many wonders of Pascals triangle
4. Robotic Telescope Observations - Las Cumbres Global Telescope Network - Pat & Grady Boyce Foundation Grant & LCO
5. Building a Paper Telescope and exploring the nature of light
6. Observe Sunspots, Solar Prominences using Sunspotter - Tom Field Grant, Astronomer, Contributing Editor Sky & Telescope Magazine
7. Calculate the Diameter of the Sun
8. Overnight start party to obtain the Stellar Spectrum of Rasalgethi - a Red Supergiant Star
9. ~~Raspberry PI Bird Observatory~~ (ran out of time …)
10. Measure the Diameter of a Carbon Atom using Oleic Acid
11. Obtain Spectrum of Hydrogen, Helium, Neon, Mercury, Terbium, and Europium!
12. Physical Computing with Raspberry PI - LEDs & Buttons
13. Observe Sprouts grow using Time Lapse Animation

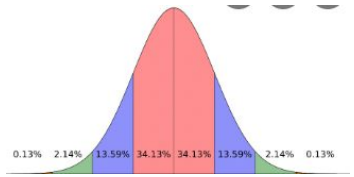
Citizen Science Expo!

- Students invite assembled parents and teachers to the Citizen Science Expo
- Show of your results!!
- Students WILL ASK QUESTIONS OF PARENTS - THEY HOPE YOU PREPARED!
- Enjoy the final day of the workshop

Daily Schedule at a glance - Week 1

Day 1 Mon Aug 8	Introductions! Survey course materials and resources. Form teams of 2 or 3. Importance of making notes in your individual notebook! Play with dice, Prediction of Probabilities. Analyze results. Build and experiment with the Galton Board, Pascal's Triangle, Fibonacci Numbers Analyze results.
Day 2 Tue Aug 9	Los Cumbres Observatory Global Telescopic imaging. Start time-lapse images using Raspberry PI of sprouting plants. Google Colab, Experiments & Charting Probabilities & Normal Distributions - Scientific Method.
Day 3 Wed Aug 10	Astronomer Tom Fields visit - Look at the surface of the Sun through a Solar Telescope, Use the Sun Spotter image projector, Measure the Diameter of the Sun, explore how big the Sunspots are! Image and document results
Day 4 Thu Aug 11	Powers of 10, Exponents, Measure diameter of Atom. Electron Shells and How is light made in the Sun and in a lamp? Build & use a Paper Spectroscope - Take images of sunlight and lamps.
Day 4 Night Thu Aug 11	Observing night at the Ryther campus! We will be taking Spectral images of stars. We will also image more nebulae, galaxies, and star clusters





Daily Schedule at a glance - Week 2

Day 5 Mon Aug 15	Build Wooden Raspberry PI Spectroscope. Calibrate instrument. Take spectra of various Emission Gas Tube Spectra. Compare your results with National Institute of standards data
Day 6 Tue Aug 16	Raspberry PI - Learn to use. Use breadboard to make electronic circuits with Camera, Buttons, LED and Motion Detectors. Stop-Motion Animation exercise starts
Day 7 Wed Aug 17	~~Raspberry PI - Build Bird Observatory for recording and identifying bird calls.~~ Examine time-lapse pictures, make GIF files. Continue Stop Motion exercise. Prepare for the Science Expo tomorrow!
Day 8 Thu Aug 18	Citizen Science Expo in the Park. Students will setup and present their results to the parents!

Welcome!

State your name - how would you like to be addressed

What are your preferred pronouns!

What attracted you to this workshop?

Say one thing about you that others will find interesting!

We will build, explore and have fun!

Please use your notebooks!

What we will learn?

Measure the sizes of things very BIG and very small through experimentation!!

Learn the Scientific Method

Build a Raspberry PI computer and use it in this workshop - Take and analyze images, Build electronics on a breadboard, stop-motion animation, time-lapse photography, Build a Bird call observatory

Learn some fun Computing Mathematics & Physics visually and by doing - Galton Board, Spectroscope, Sunspots, Operate Telescopes around the world

Share with Parents and friends!

Where do we go - what do we build & use?

- Daily Slides (this), Google Drive, Gmail
- Build Galton Board, Sun Spotter, Lunt Solar Telescope to see the surface of the Sun
- Build Raspberry PI, Time-Lapse Photography
- Build Paper Spectroscope
- Build Wooden Spectroscope
- Build Bird Observatory
- Measure the Diameter of the Atom
- Make Time-lapse & Stop-motion animation videos

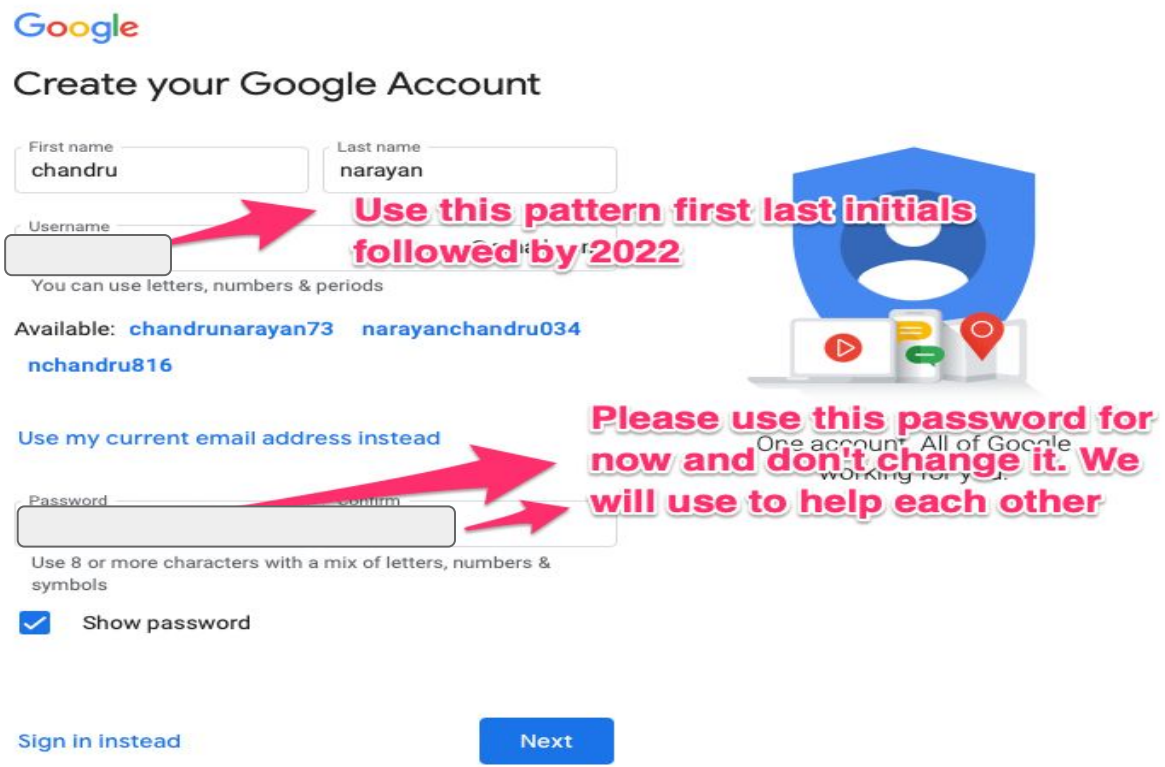
Let's create a Google Account for this workshop!

From your Chrome or Safari browsers (preferred) start a "Private Window" or "Incognito Window"

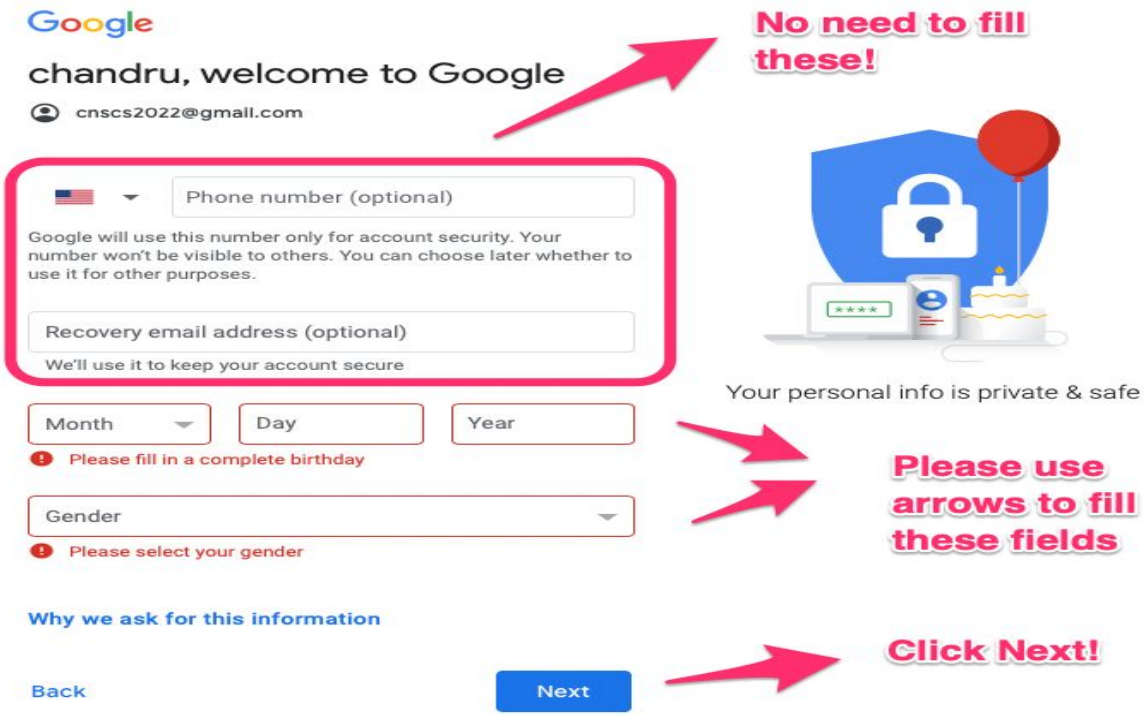
In the address bar type in "Create Google Account" and click the link to create one!

Follow the slides below to complete creating the account

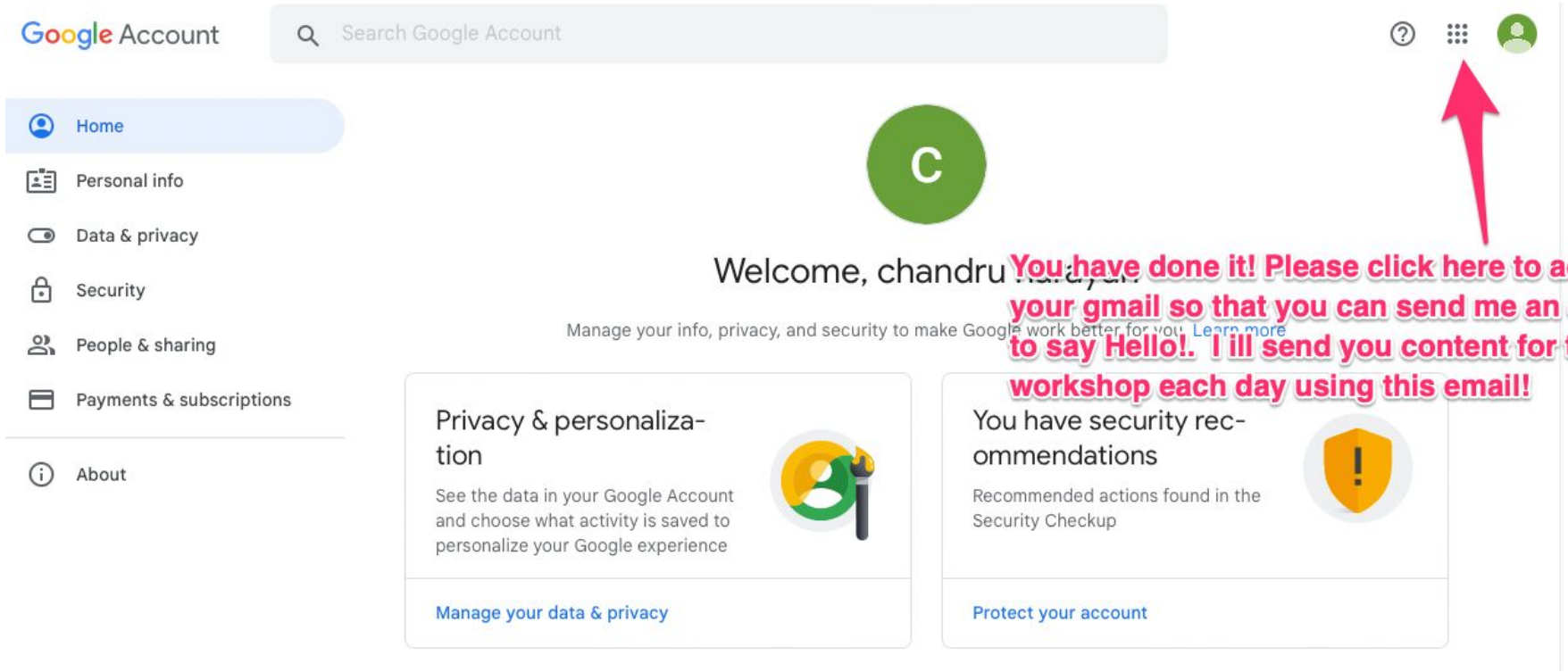
Username & Password



Fill out the welcome to Google screen as shown



You have done it! We can get started!



Monday
Day 1
Galton Board!

Day 1 - Build a Galton Board - Learn about Probability

We will understand the basics of probability and make predictions about dice and random events

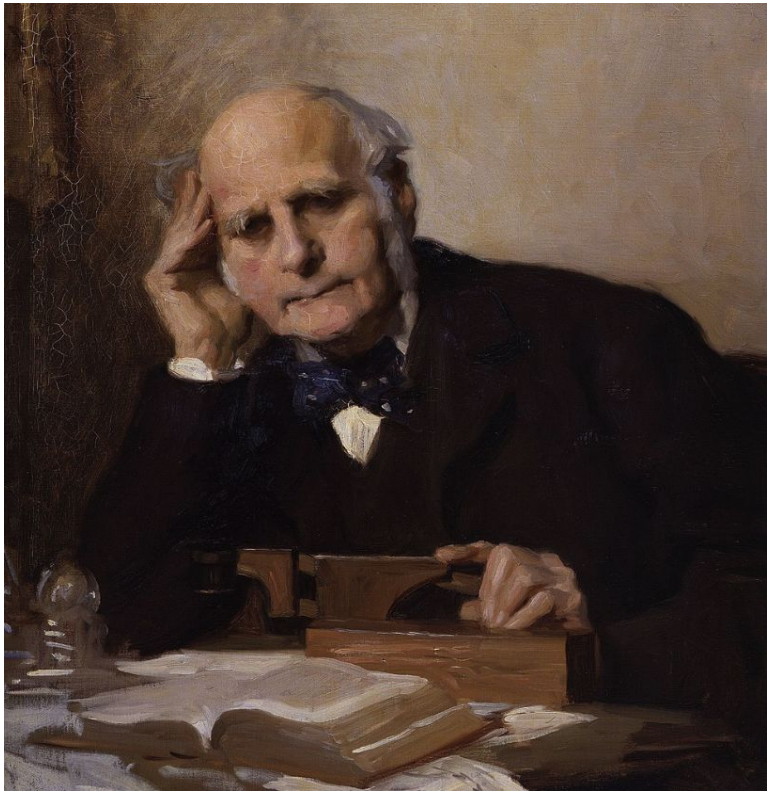
We will build a Galton Board to learn about the Pascal's triangle, statistics, Fibonacci numbers, golden ratio and Normal distributions in Nature

We will use Google Colab to simulate nature and draw bell curves on the computer. We can compare our experimental numbers from the Galton board to our predictions!

This is the Scientific Method!

Use this worksheet for today's labs

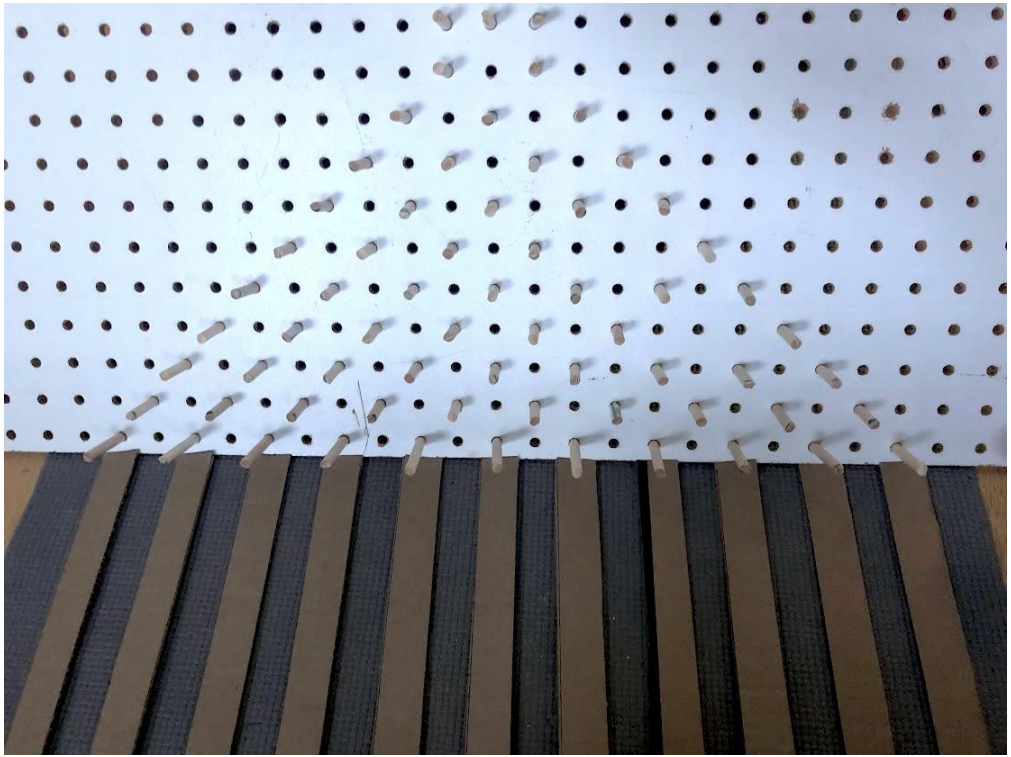
Who is sir Francis Galton?



Sir Francis Galton, FRS FRAI (/ɡɔːltən/; 16 February 1822 – 17 January 1911), was an English Victorian era polymath: a statistician, sociologist, psychologist,[1] anthropologist, tropical explorer, geographer, inventor, meteorologist, proto-geneticist, psychometrician and a proponent of social Darwinism, eugenics, and scientific racism. He was knighted in 1909.

He invented the Galton Board in 1860

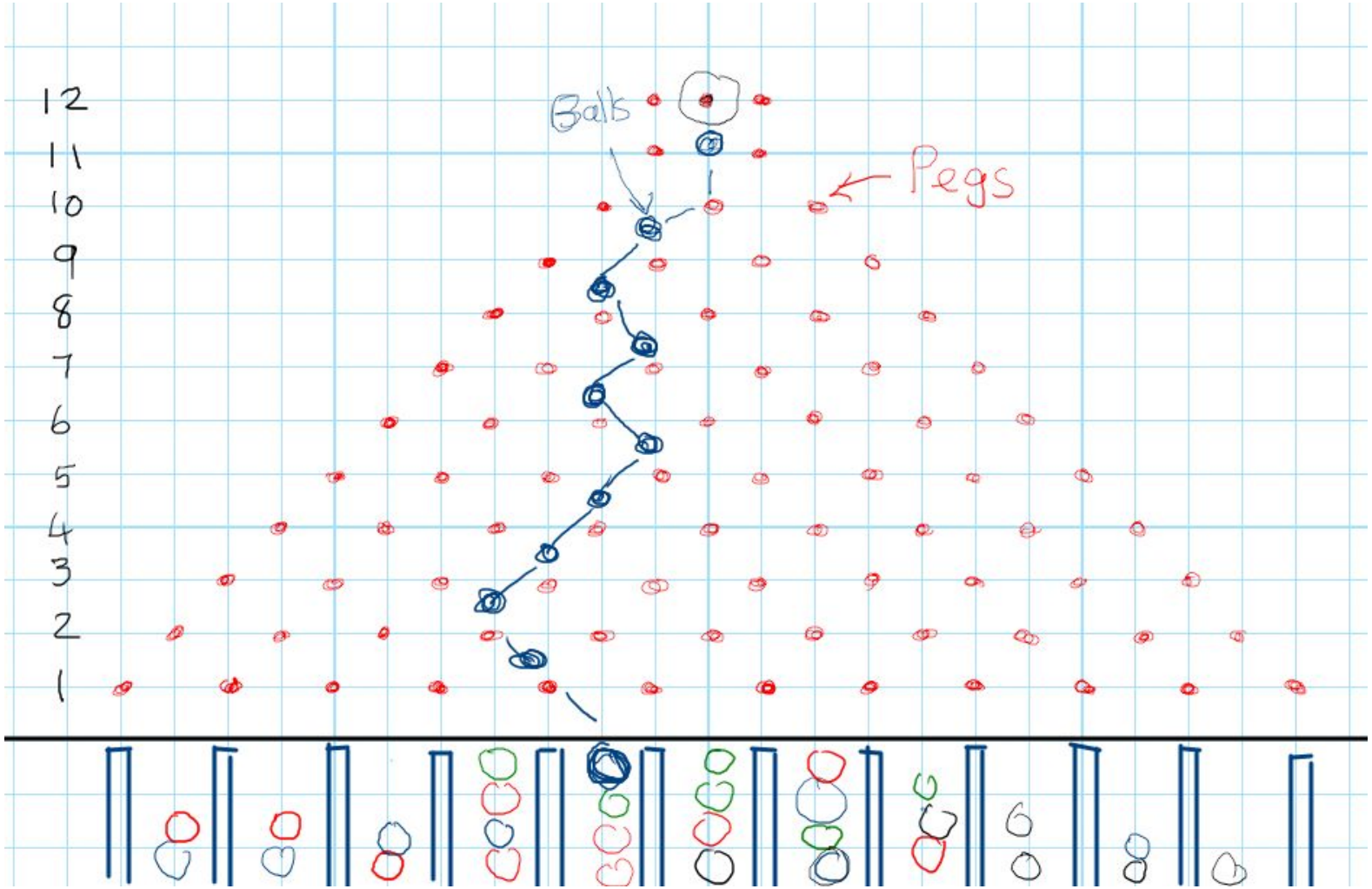
Build the Galton Board using the Peg Board and dowels



1. Follow the pattern per the image, Be Precise!
2. All students to contribute
3. Lightly Tap in the Dowels
4. Use a small amount of blue tape on the underside of the cardboard strips to form the columns
5. The Peg board should be at a 60 degree angle from the horizontal
6. Use the Measure or level app on the phone provided
7. Balls has to traverse through the board without skipping pegs. If it does, it is too steep
8. If any ball skips send it through again

Running the experiment!

1. Form 3 teams 2 students. We will assign team numbers. Write your team number and your team mate name in your notebook
2. Each team will do 2 trials of running all the balls through the system. You can practice with a few first)one at a time) to see how it all works.
3. One student drops balls one at a time from the very top just underneath the central peg on the top row
4. Second student careful watches the balls to make sure it flows through the system properly
5. Third student lines up the balls in each bin (between cardboard strips) and make sure it does not skip to another bin. If so, pick it up and put it in the right bin rolling it down to the very end!
6. Fourth Student takes a picture of the bins enters the balls in each bin into the Google Sheet provided in the appropriate cells

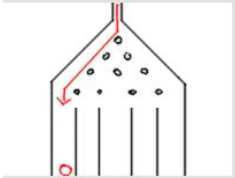

12
11
10
9
8
7
6
5
4
3
2
1
Balls
Pegs

Back to the Galton Board workshop!

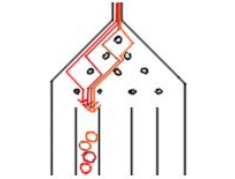
When a ball approaches a peg what choices does it have?

Given a position on the board - can you think about the multiple ways in which the ball could have got there? Use a simple board and positions shown

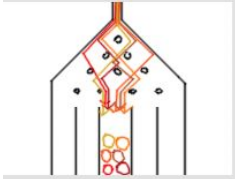
Probabilities!



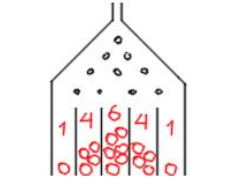
There's only one way for a ball to reach the first column



There are four ways to reach the second column

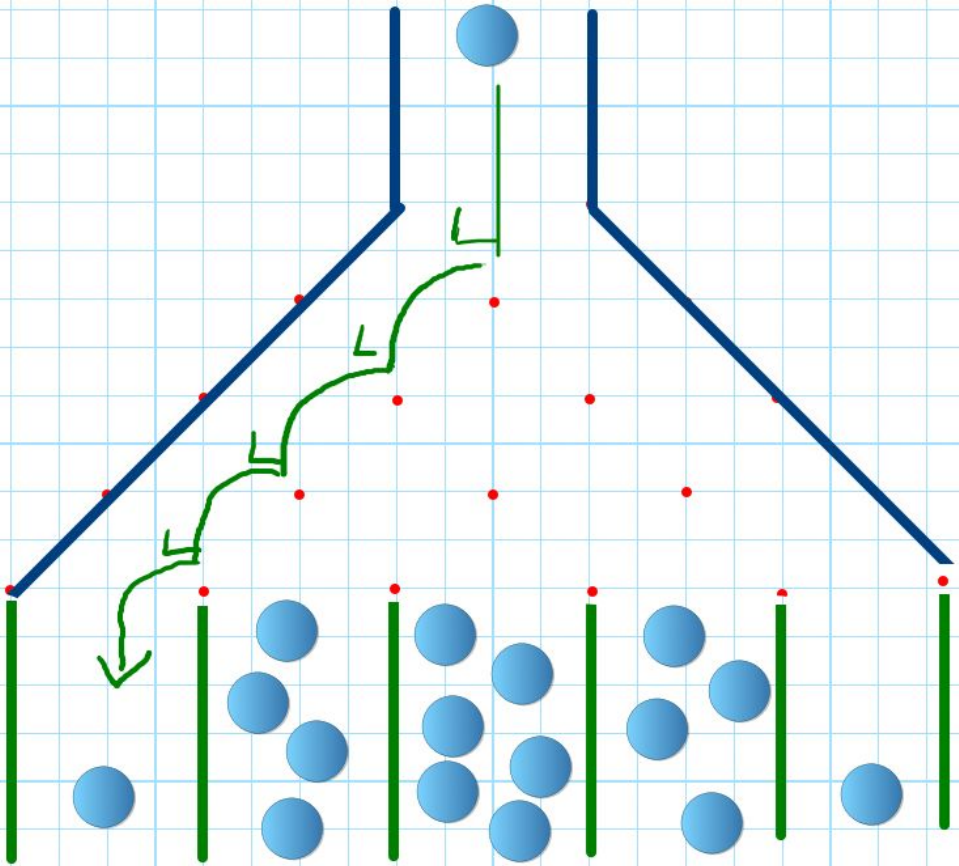


There are six ways to reach the third column

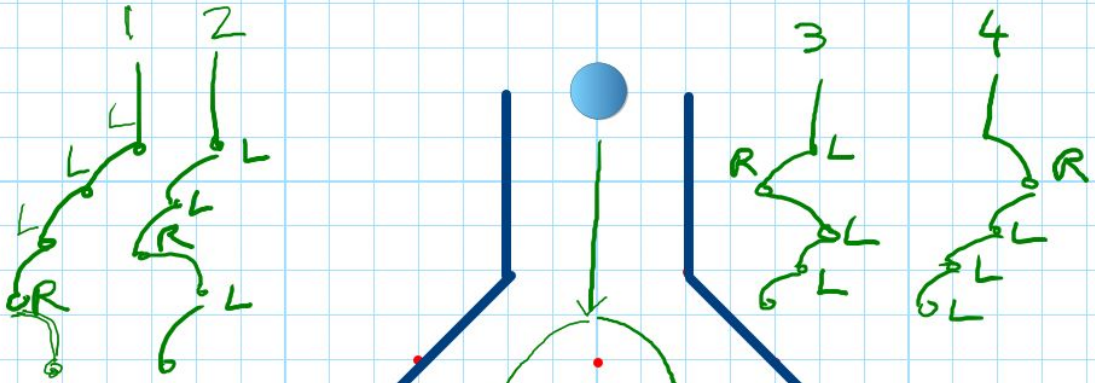


Because the machine is symetrical, after some time it will look like a gaussian distribution

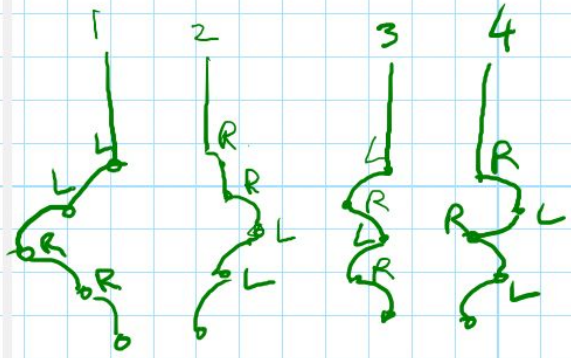
How many ways can you arrange 4 L's ?



How many ways you can arrange 3 L's and 1 R ?



How many ways in which you can arrange 2 Rs & 2 Ls ?



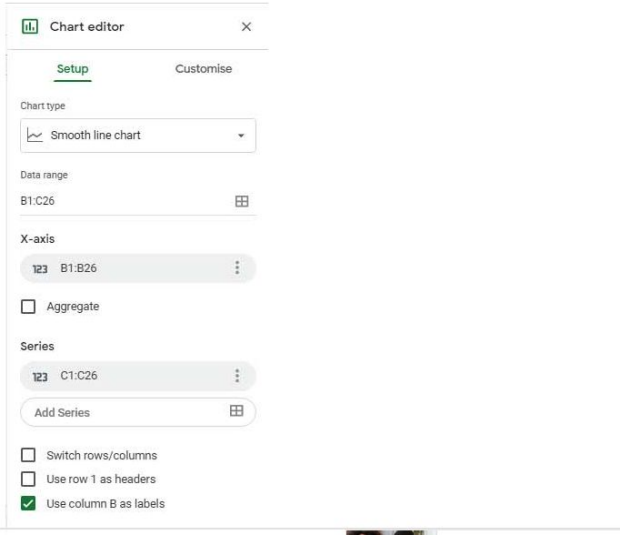
More ??

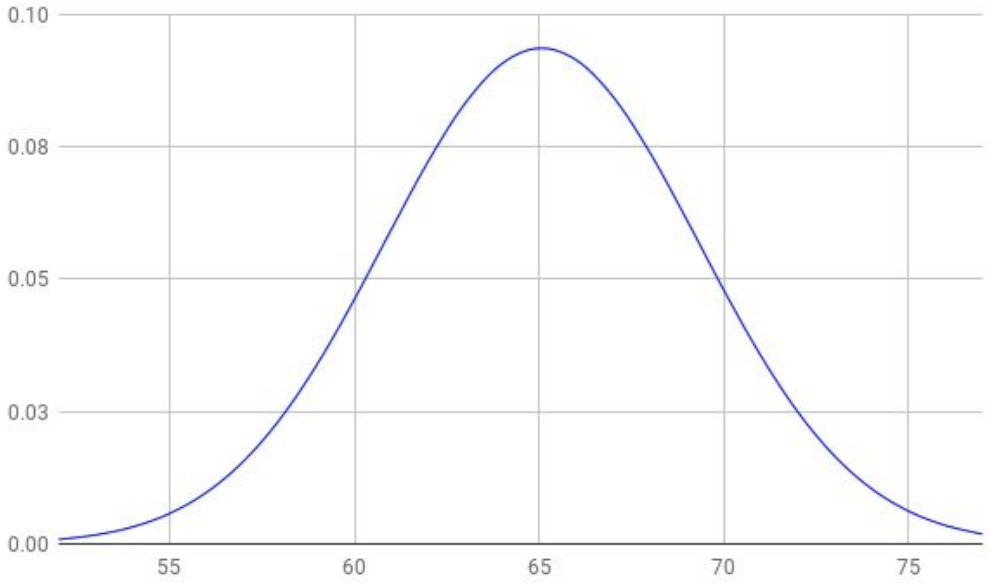
Using Google Sheets to visualize our Normal Distribution!

Smooth Line Chart for Plotting Bell Curve in Google Sheets

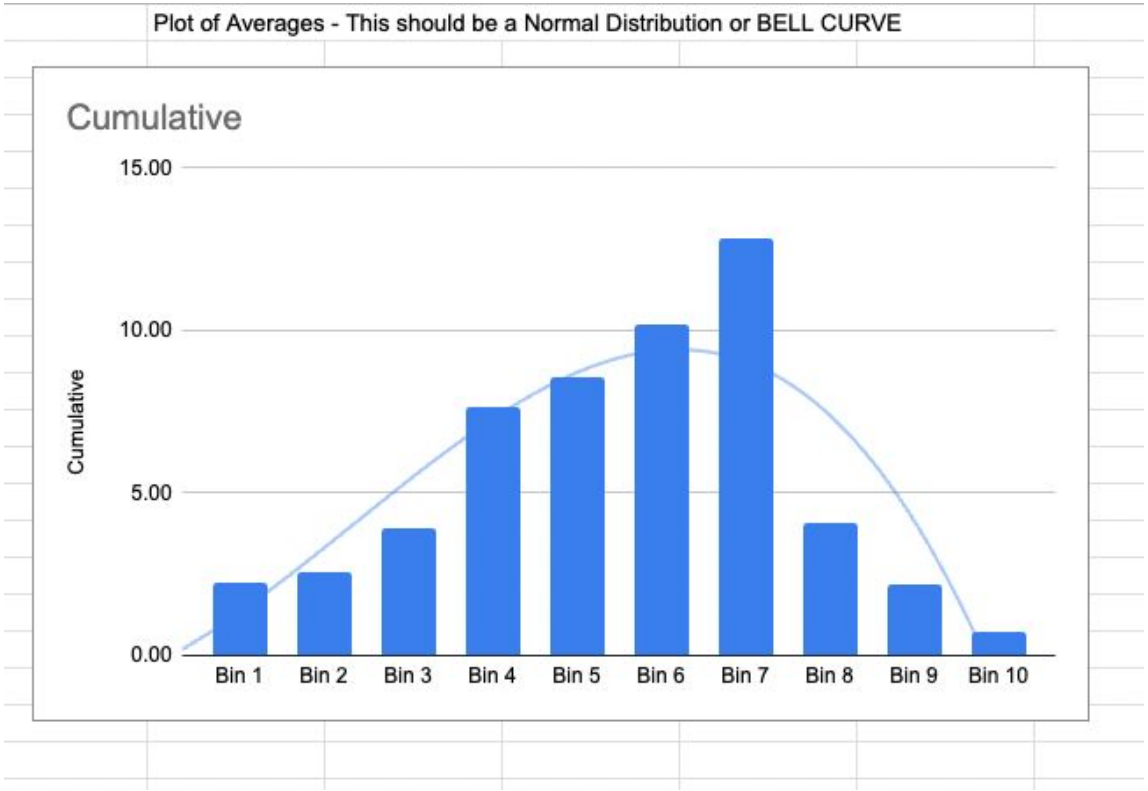
To plot the bell curve in Google Sheets, we must use the **Smooth line** graph. Here are th steps.

Select the data in B1:C26. Then click on the "Insert" menu to open the drop-down and cl on "Chart". Select the chart type "Smooth line chart" and make a tick (to enable) in front "Use column B as labels".





Our Galton Board Results - The Normal Distribution!

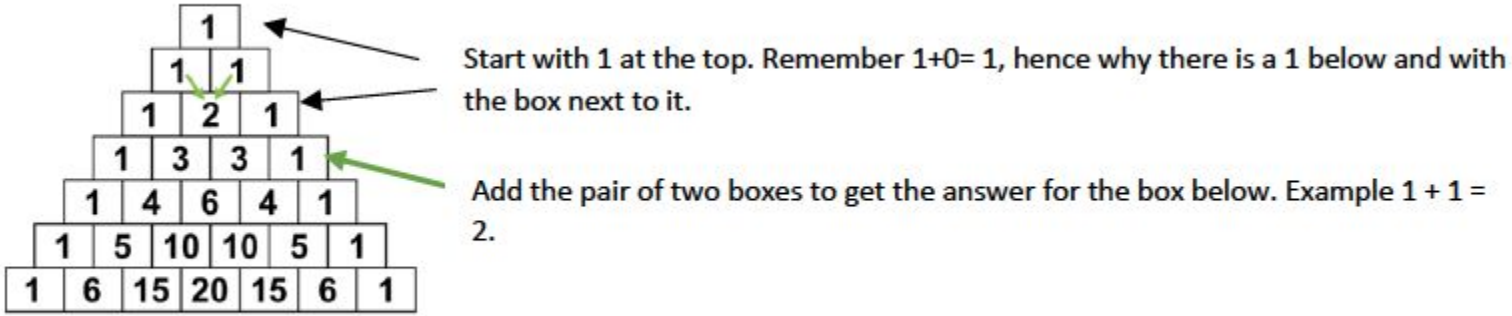


We sent 330 balls cascading through our Galton Board in 3 separate teams. The Normal Distribution curve is plotted to the left!

Do you see anything interesting ??

Build a Pascal's Triangle - it is a treasure house!!

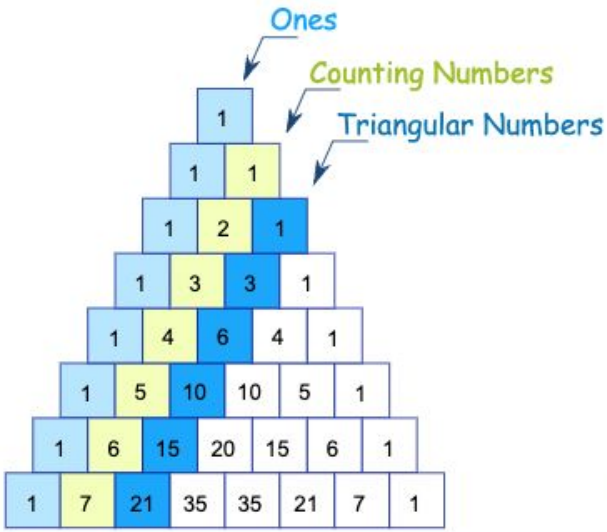
Draw the Pascal's triangle in your notebook for our specific Galton board and write in the numbers as shown below



What numbers did you get for the last row??

Triangular - Counting - Tetrahedral Numbers in Pascal's Triangle!

Patterns Within the Triangle



Diagonals

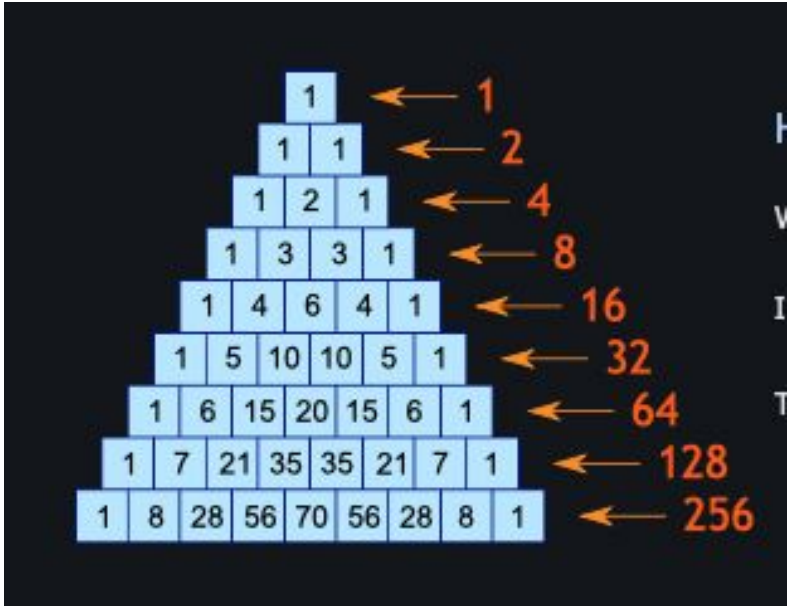
The first diagonal is, of course, just "1"s

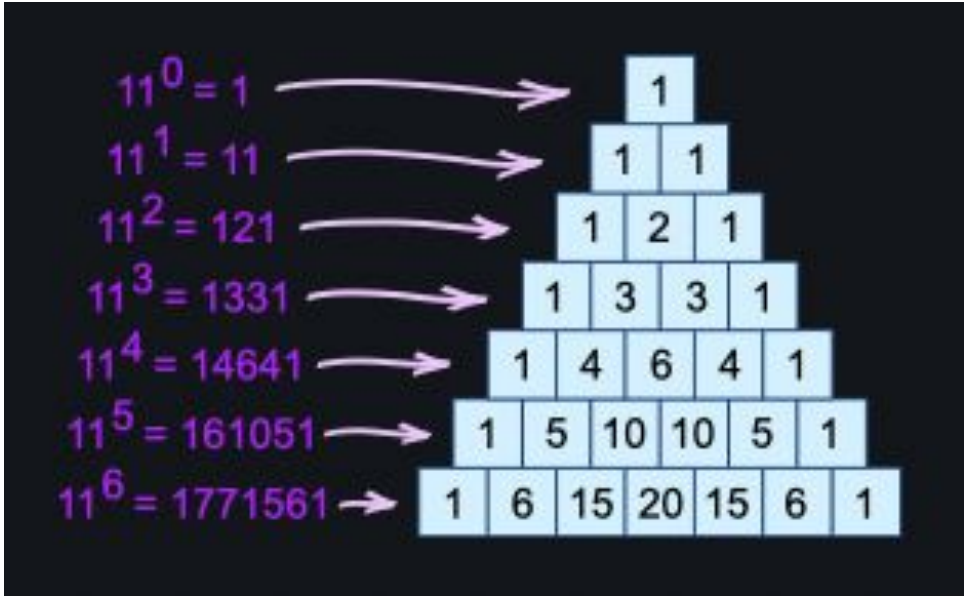
The next diagonal has the Counting Numbers (1,2,3, etc).

The third diagonal has the triangular numbers

(The fourth diagonal, not highlighted, has the tetrahedral numbers.)

Horizontal Sums - Exponents of 11 - in Pascal's Triangle!





What is a fibonacci sequence?

The Fibonacci Sequence is the series of numbers:

(, 1, 2, 3, 5, 8, 13, 21, 34, ...

The next number is found by adding up the two numbers before it:

- the 2 is found by adding the two numbers before it (1+1),
- the 3 is found by adding the two numbers before it (1+2),
- the 5 is (2+3),
- and so on!

Example: the next number in the sequence above is 21+34 = **55**

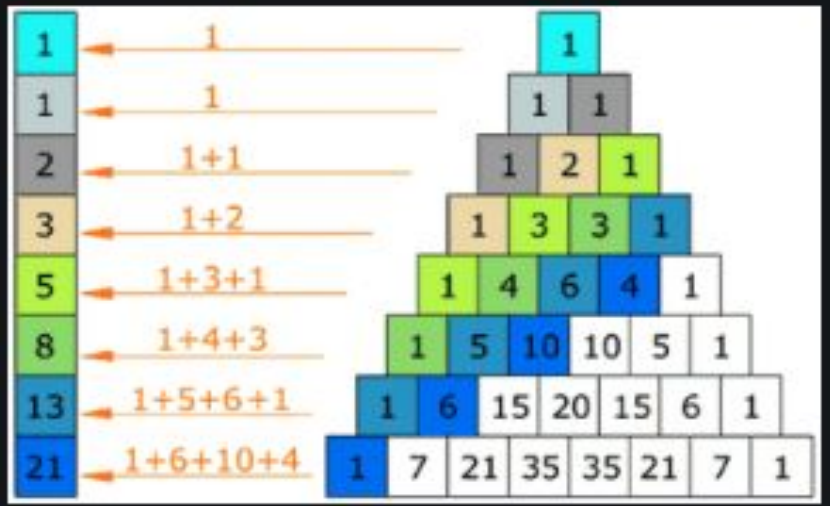
Please calculate and list the first 15 numbers of the fibonacci sequence!
Verify the answer!

Fibonacci Numbers in Pascal's Triangle

Fibonacci Sequence

Try this: make a pattern by going up and then along, then add up the values (as illustrated) ... you will get the Fibonacci Sequence .

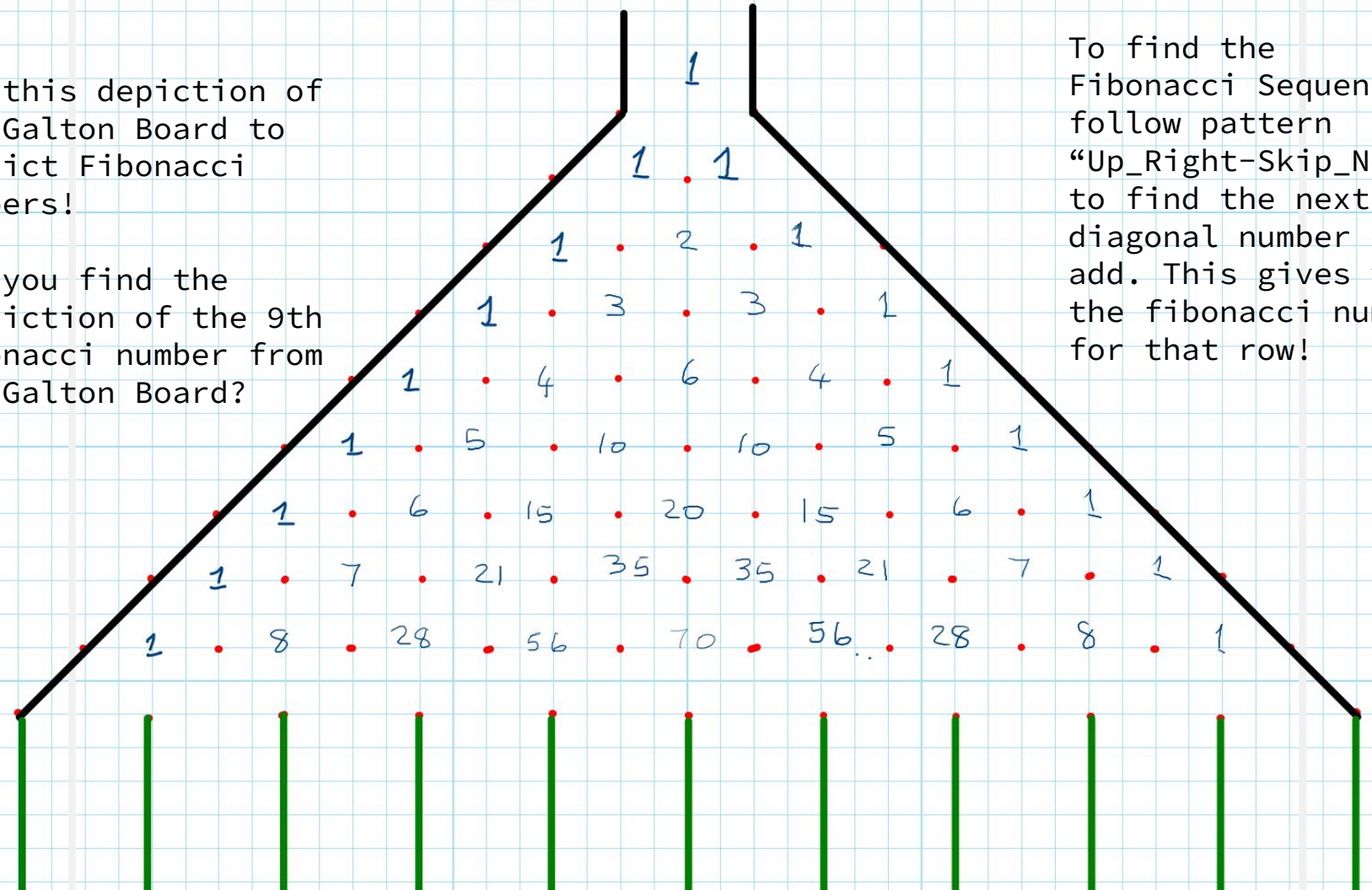
(The Fibonacci Sequence starts "0, 1" and then continues by adding the two previous numbers, for example 3+5=8, then 5+8=13, etc)



Use the formula "Up_Right-Skip_Next" to find the next diagonal number. Add all of these together (except Skip) to get the fibonacci number! Can you find the fibonacci sequence in the Pascal's Triangle for our Galton Board?

Use this depiction of out Galton Board to predict Fibonacci Numbers!

Can you find the prediction of the 9th Fibonacci number from our Galton Board?



To find the Fibonacci Sequence follow pattern “Up_Right-Skip_Next” to find the next diagonal number to add. This gives you the fibonacci number for that row!

Fibonacci number worksheet

Please now calculate and list the first 15 numbers of the fibonacci sequence! Verify the answer!

Then calculate the ratio of every 2 consecutive numbers of the fibonacci sequence!

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	2	3	5	8	13	21	34	55	89	144	233	377	610
	1	2	1.5	1.666	1.600	1.625	1.615	1.619	1.618	1.618	1.618	1.618	1.618	1.618

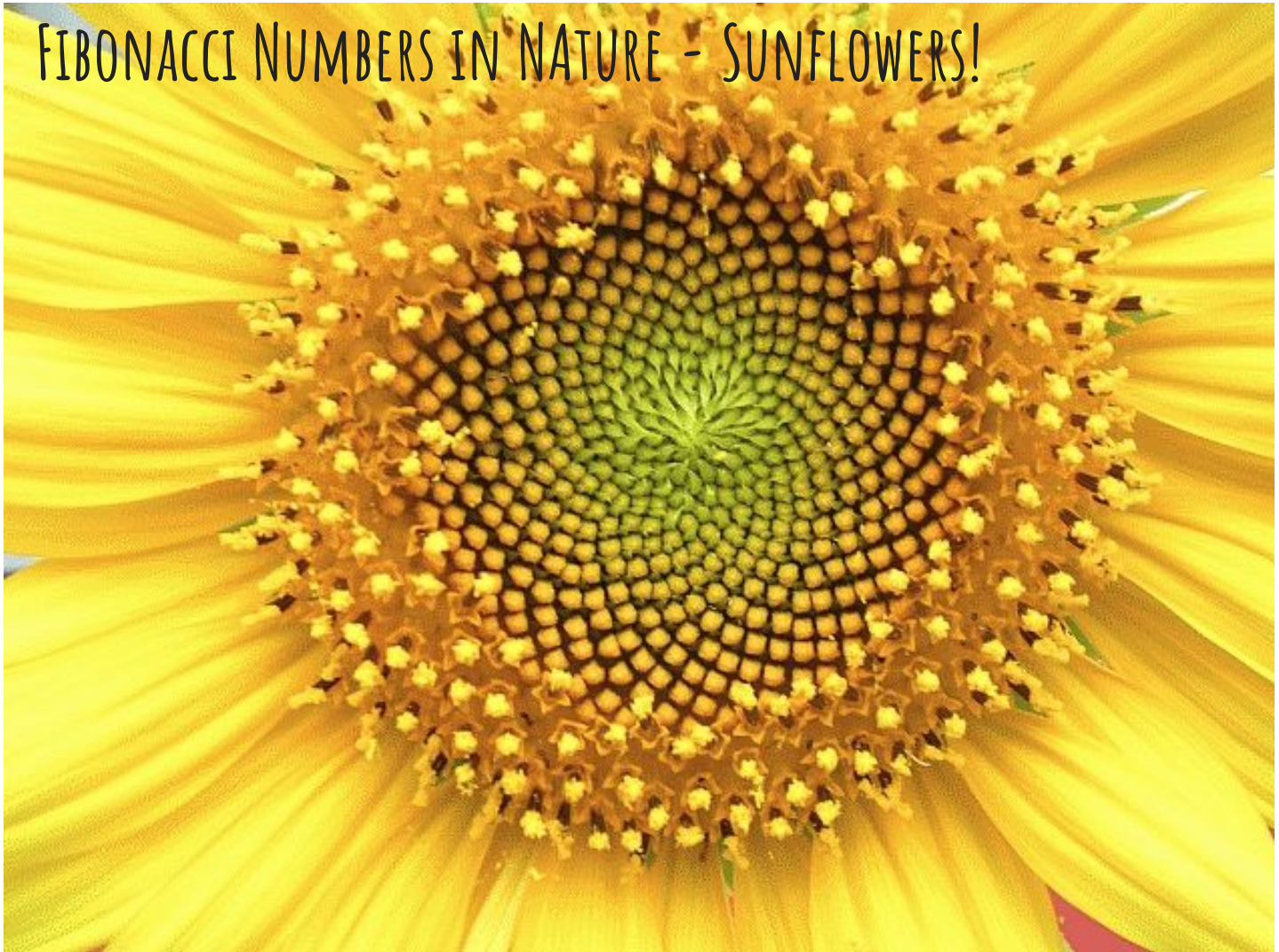
What are your observations ??

Fibonacci Numbers in Nature - Pine Cones!

Let’s find them!
Get a Pine Cone from the instructor
Ink in the spirals
Count the Spirals going both ways!
Write the numbers in your notebook
What did you find?

Ask a student to show how you can find fibonacci numbers in the pine cone?

Fibonacci Numbers in Nature - Sunflowers!



- Let's find them!
- Ink-in both the clockwise & anticlockwise the spirals
- Count the Spirals going both ways!
- Write the numbers in your notebook
- What did you find?

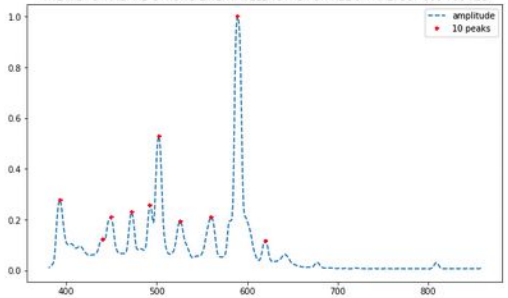
Google Colab - Jupyter Notebooks - Charting

```
#       Print the Spectral Peaks table of wavelengths
#       for current spectral image obtained
csv_tbl_filename = tbl_filename + ".csv"
bdslibv2.export_csv(tbl_filename, normalized_results)

#       Uncomment and change these thresholds if necessary if
#       you would like to increase or decrease the number
#       of Spectral peaks found

#samp_th = 0.2
#wlen_th = 10
#       Call function to draw the Spectral Peaks which will
#       Plot the peaks and return a list of Peak Wavelengths
pks_png_filename = pks_filename + ".png"
peak_wl, t1, t2 = bdslibv2.draw_spectral_line_peaks(element,csv_tbl_filename, pks_png_filename, desc, samp_th, wlen_th)
bdslibv2.display_bds_params(name,desc,shutter,slit_topadj,slit_botadj,spectrum_angle,wavelength_factor,samp_th,wlen_th)
par_txt_filename = par_filename + ".txt"
bdslibv2.write_bds_params(par_txt_filename,name,desc,shutter,slit_topadj,slit_botadj,spectrum_angle,wavelength_factor,samp_th,wlen_th)
```

```
Title:            PERFECT HELIUM SPECTRUM FROM A HELIUM DISCHARGE TUBE
BDS parameters used for this run:
Spectrum Base Name is            Helium0804162905
Camera Shutter is:               100000
Slit Top Adjustment is:          100
Slit Bottom Adjustment is:       -35
Camera Spectrum Angle is:        0
Camera Wavelength Factor is:     0.77
Amplitude Threshold is:          0.1
Wavelength Threshold is:         10
                    SPECTRAL PEAK WAVELENGTHS FOR HELIUM
THE MEASURED PEAK WAVELENGTHS FOR HELIUM IN NANO_METERS ARE: 393 440 449 472 492 502 526 560 589 620
                THE NIST STANDARD STRONG LINE WAVELENGTHS FOR HELIUM ARE: 587 668 706 728
```



Tuesday
Day 2
Remote Telescopes
Fibonacci numbers

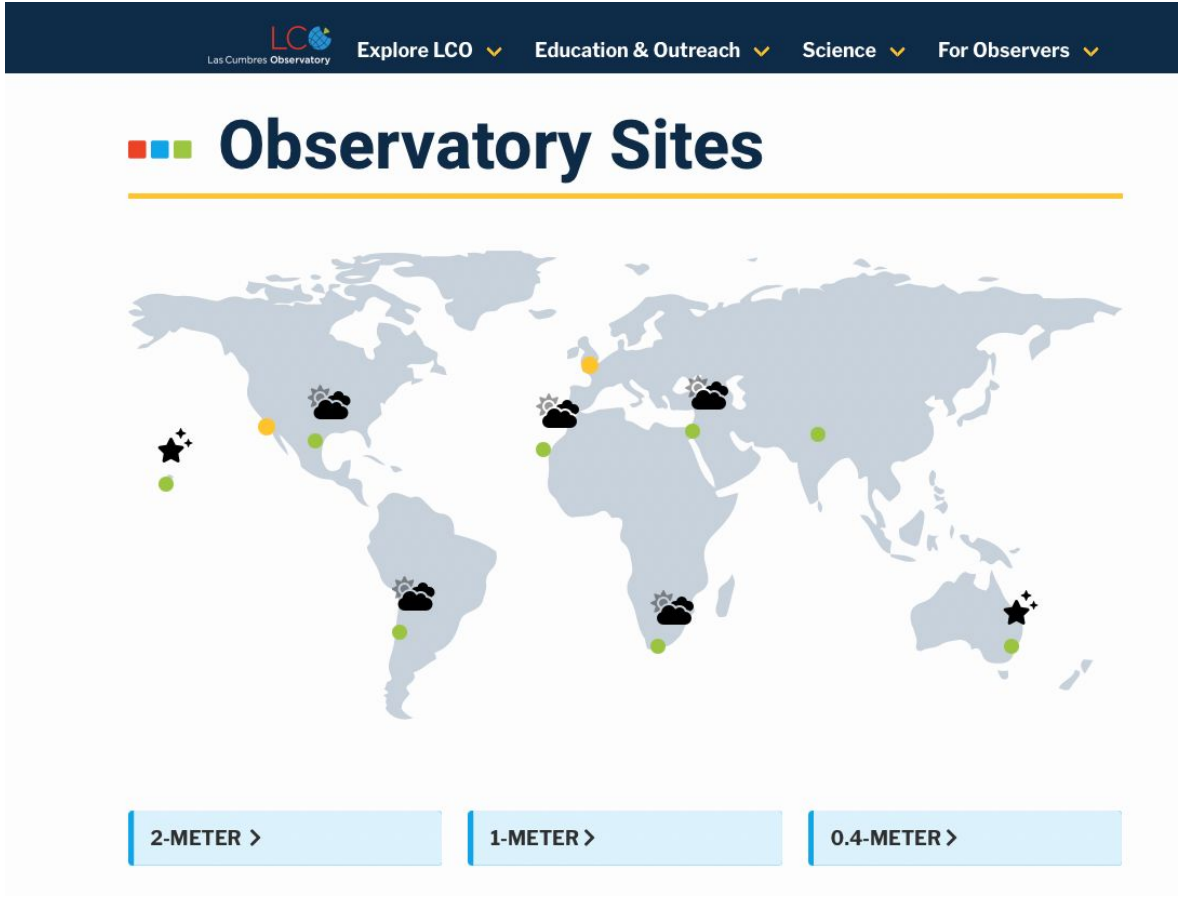
Remote Telescopes Pascal's Triangle & Raspberry PI

- Schedule Observations via Robotic Telescopes!
- Complete Galton Board Exercise by constructing and learning about the Pascal's Triangle
- Start Time-lapse imaging of sprouting plants using Raspberry PI

Las Cumbres Global Observatories!

Made available by a Grant provided by Pat & Grady Boyce Foundation for STEM education for children around the world!

The remote robotic telescopes of the LCO



We will be using one or more of these 0.4 meter telescopes for scheduling our remote observations!

Let's look at the telescopes

Where is this Telescope?

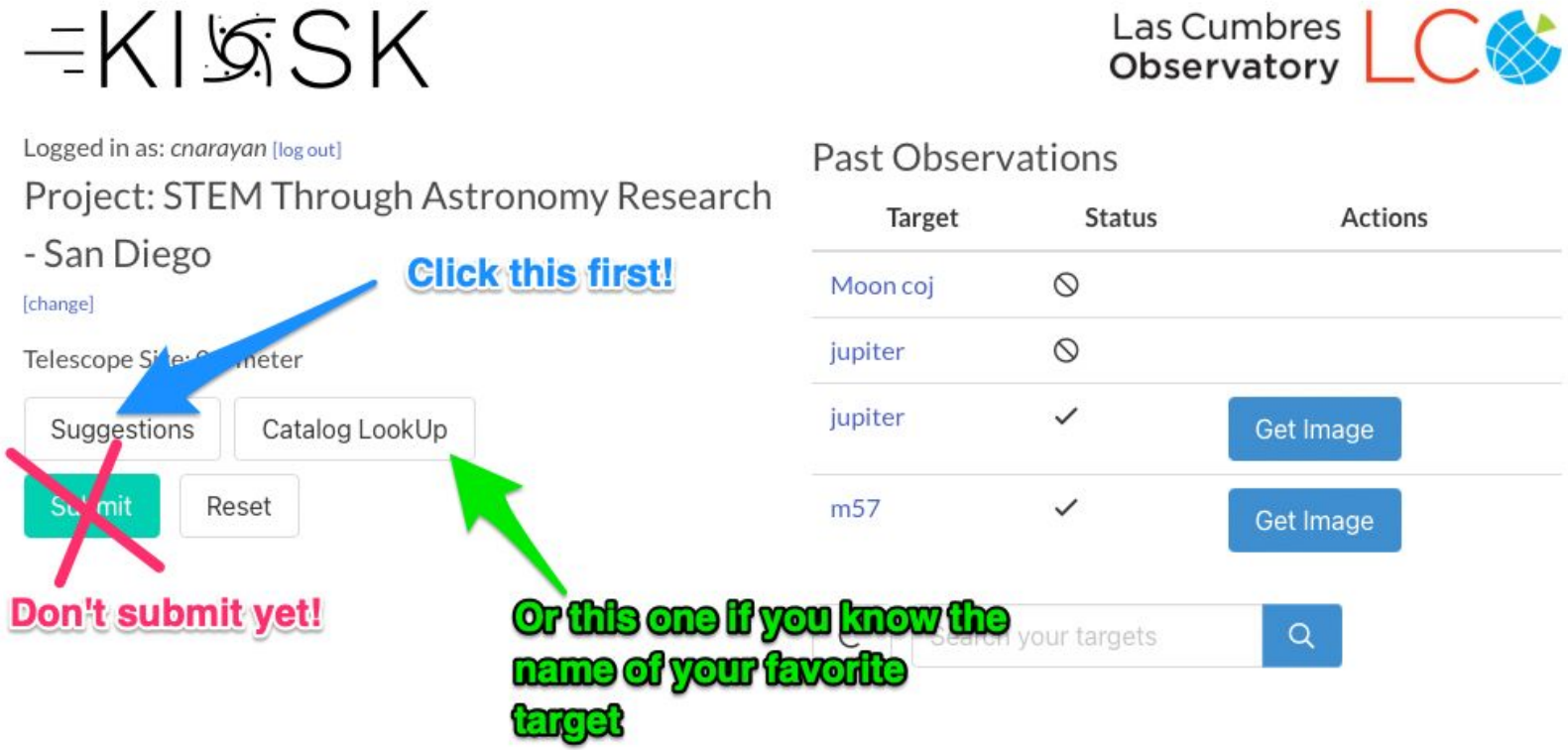
How big is it?

What kind of Telescope is this?

What else can you tell me about it?

Can we use it now?

Prepare an Observation Request - DO NOT SUBMIT YET!!



Pick one from the suggestion list

Click the suggestion list (multiple times) until you find an object that is interesting to you

OR type in a name of the object if you know one to look up

Then look up the object in Wikipedia using the proper name

Is it of interest to you? If so, send me an Gmail with the link from wikipedia! Make sure that it is not farther than 50 Million Light Years (50 MLY) from us!

We will come around to help you!

I will schedule an observation for you to examine later today!

Sombrero Galaxy

Coordinates: 12h 39m 59.4s, −11° 37′ 23″

From Wikipedia, the free encyclopedia
(Redirected from Sombrero galaxy)

For other uses, see M104 (disambiguation).

The **Sombrero Galaxy** (also known as **Messier Object 104**, **M104** or **NGC 4594**) is a peculiar galaxy of unclear classification[5] in the constellation borders of Virgo and Corvus, being about 9.55 megaparsecs (31.1 million light-years)[2] from our galaxy, within the local supercluster. It has a diameter of approximately 15 kiloparsecs (49,000 light-years),[6] three-tenths the size of the Milky Way. It has a bright nucleus, an unusually large central bulge, and a prominent dust lane in its outer disk, which is viewed almost edge-on. The dark dust lane and the bulge give it the appearance of a sombrero hat. Astronomers initially thought the halo was small and light, indicative of a spiral galaxy; but the Spitzer Space Telescope found that the dust ring was larger and more massive than previously thought, indicative of a giant elliptical galaxy.[7] The galaxy has an apparent magnitude of +8.0,[6] making it easily visible with amateur telescopes, and is considered by some authors to be the galaxy with the highest absolute magnitude within a radius of 10 megaparsecs of the Milky Way.[4] Its large bulge, central supermassive black hole, and dust lane all attract the attention of professional astronomers.

Contents [hide]

Sombrero Galaxy

Image taken by Hubble Space Telescope, October 2, 2004

Observation data (J2000 epoch)

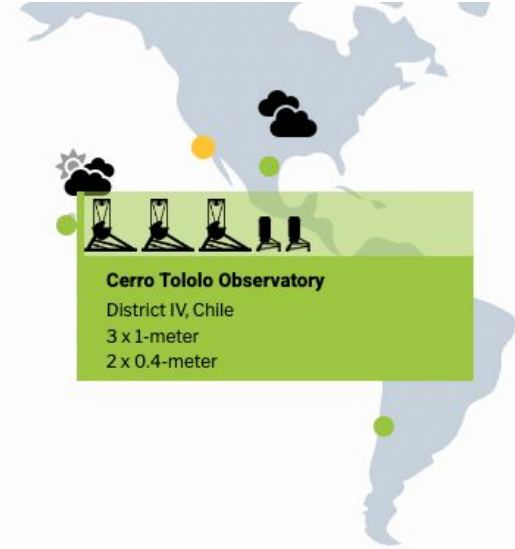
Constellation	Virgo
Right ascension	12h 39m 59.4s[1]
Declination	−11° 37′ 23″[1]
Redshift	0.003416 ±0.000017[1]
Helio radial velocity	1,024 ±5 km/s[1]
Galactocentric velocity	904 ±7 km/s[1]
Distance	9.55 ± 0.31 Mpc (31.1 ± 1.0 Mly)[2]
magnitude (V)	8.0[3]
Absolute magnitude (B)	−21.8[4]
haracteristics	
T	SA(s)a[1] or E[5]
Size	15 kpc (49,000 ly)

This should be less than 50 Mly
Otherwise the image will be too small for the 0.4 meter telescope!

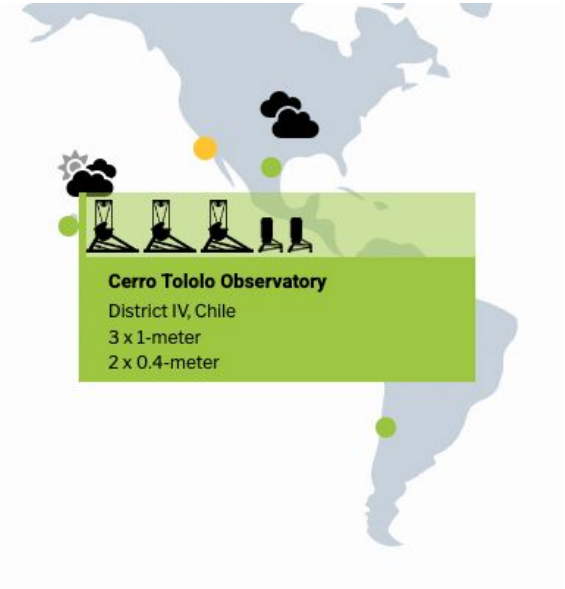
Here is an example you might choose!

Massive Spiral Galaxy M101 - Pinwheel Galaxy!

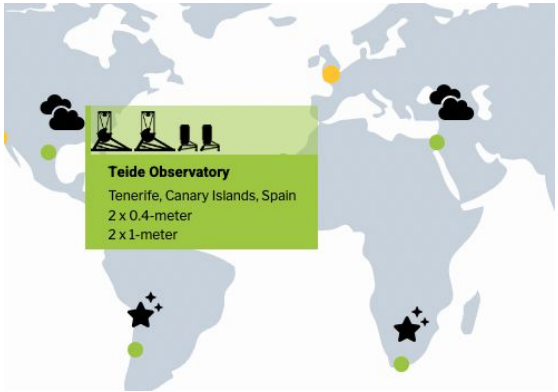
It's twice the size of the Milky way - has a Trillion Stars and is 21 Million Light Years away!



Robotic telescope images - Andromeda Galaxy M31!

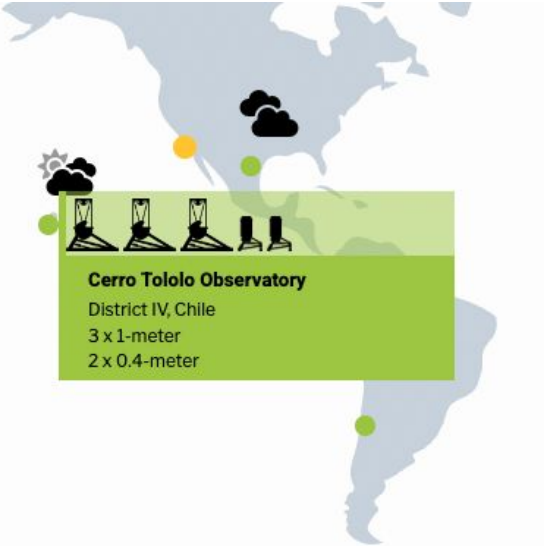


Robotic telescope images - Globular cluster m19!

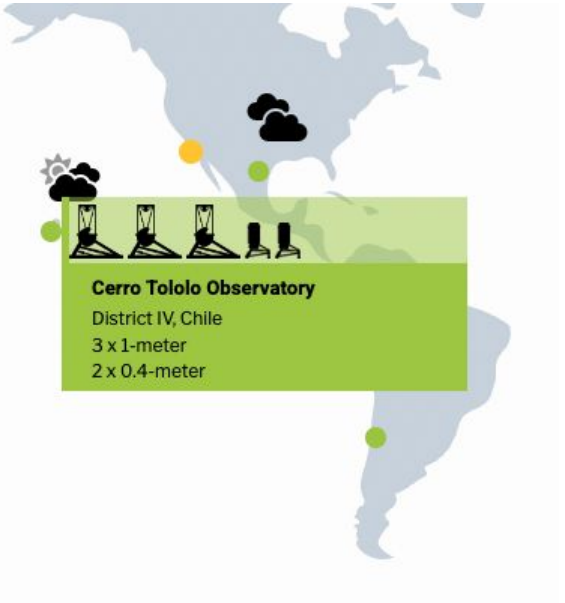


Robotic telescope images - Crab Nebula M1!

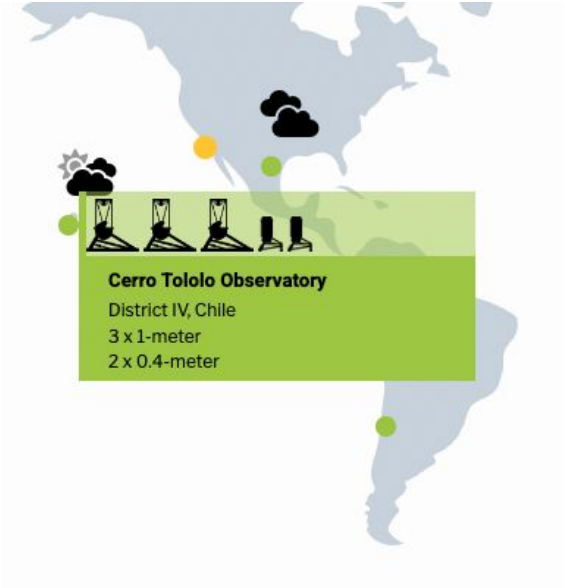
Remnants of a Supernova Explosion in the Milky Way Galaxy!



Robotic telescope images - Sombrero Galaxy m 104!



Robotic telescope images - Spiral galaxy Ngc 925!



The Observatories we got Images from!

Cerro Tololo

Cerro Tololo Inter-American Observatory is home to many NOAO telescopes. Las Cumbres Observatory deployed a full node of three 1-meter telescopes at Cerro Tololo during October 2012. We also have two 0.4-meter telescopes at this site.

For more information about the site, check out the Cerro Tololo Inter-American Observatory website.



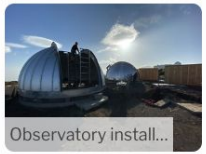
Teide

Teide Observatory, on Tenerife, is home to several types of telescopes including solar, optical, and radio. In May, 2015, two LCO 40-cm telescopes were installed here in an Aqawan enclosure. With a generous grant from the Gordon and Betty Moore Foundation, two 1-meter telescopes were installed in 2021.

For more information about the site and the current telescopes, check out the Observatorio del Teide website.

News:

- Two New Telescopes See First Light in Tenerife
- LCO Receives a Grant from the Moore Foundation to Build Two New Telescopes

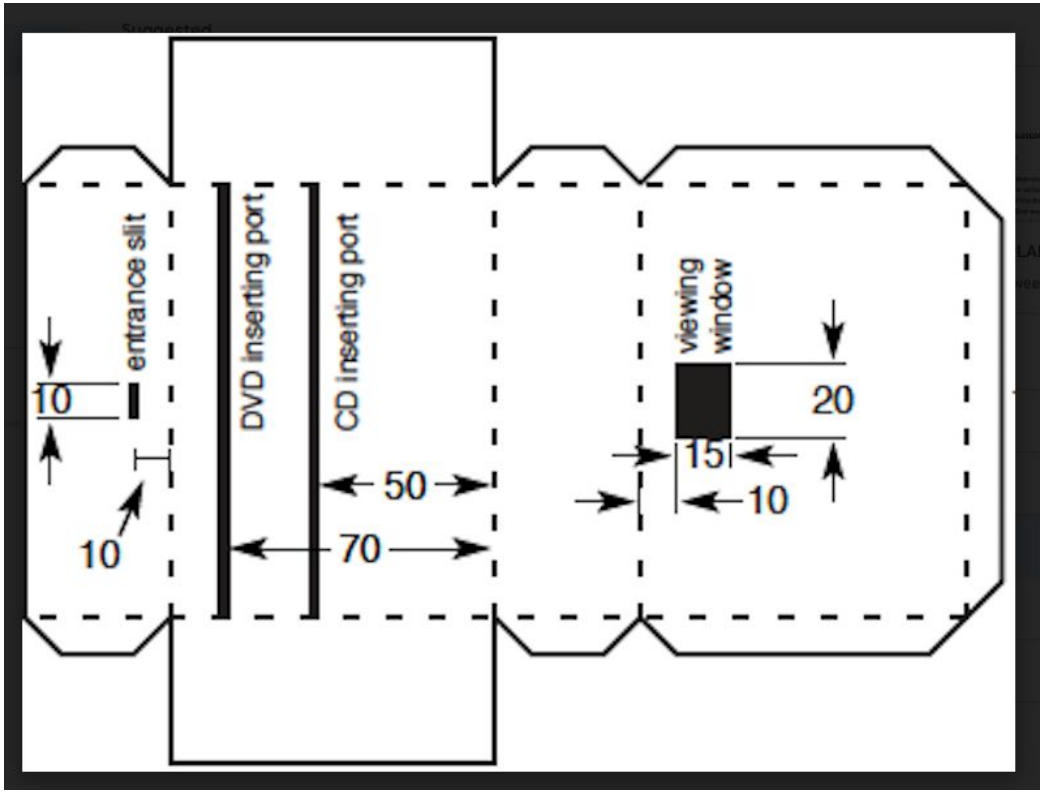


Wednesday
Day 3
Paper Spectroscope
Time Lapse rPI

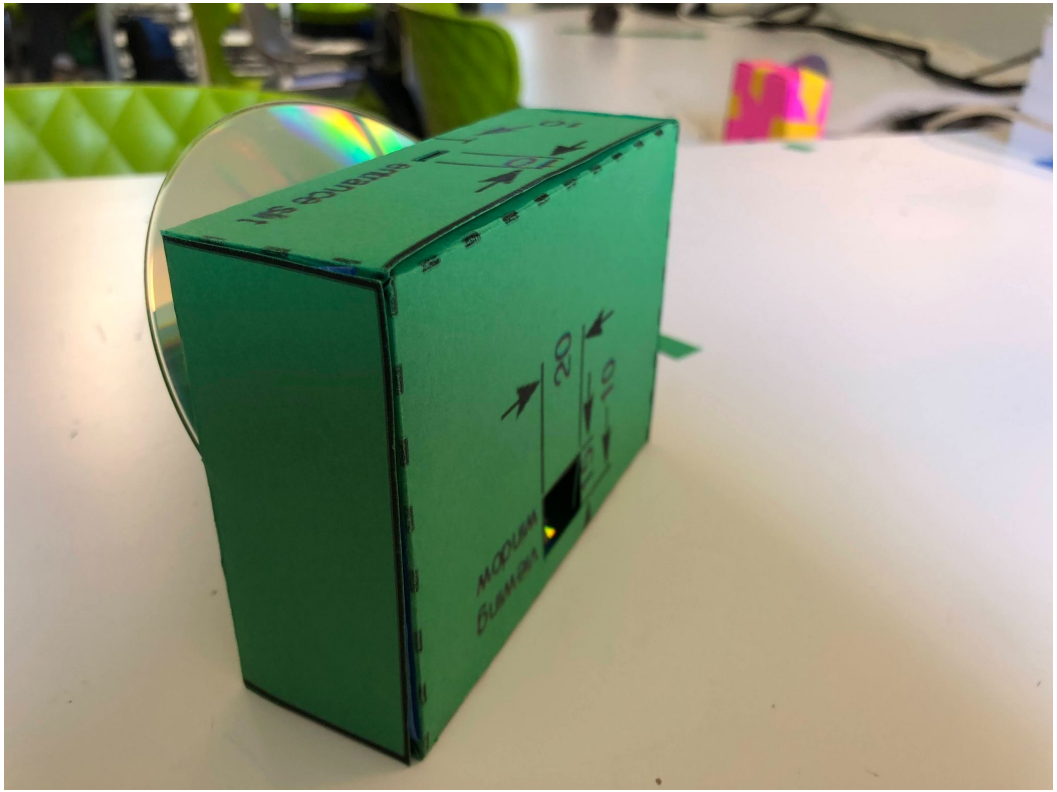
Building and using a Paper Spectroscope

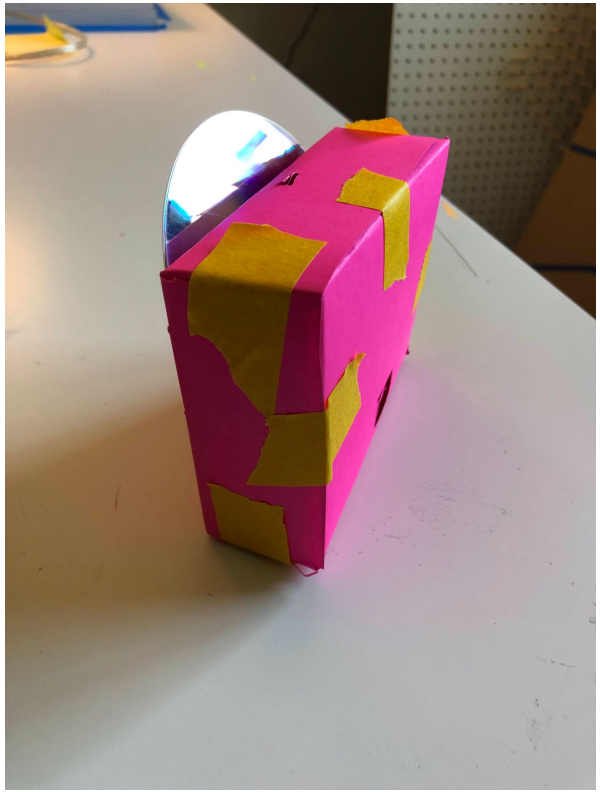
- Change wifi to Verizon 849c hotspot
- Start the day by verifying Time-lapse imaging of sprouting plants ()
  - http://rypi55.ddns.net:8888
  - http://rypi56.ddns.net:8888
- Change wifi back to SSB
- Did you complete the Fibonacci number worksheet on the next slide?
- Also count the clockwise and anti-clockwise spirals in the sunflower picture you got yesterday! What is special about them?

Building a paper spectroscope

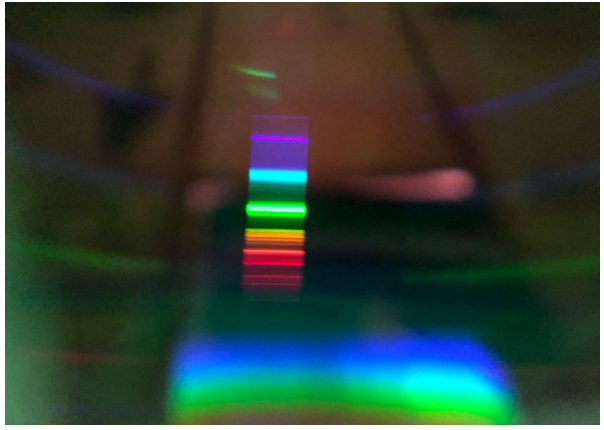


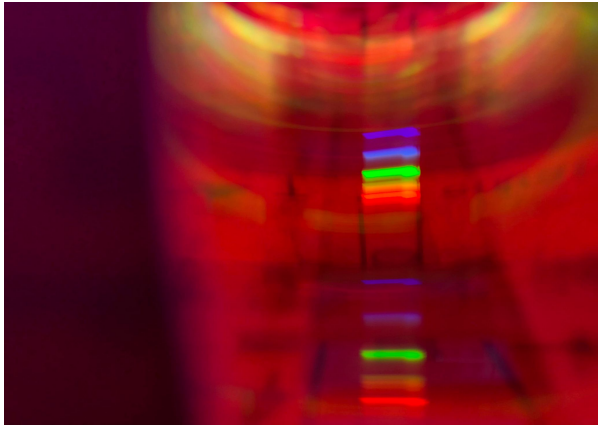
IMAGES OF STUDENT BUILT SPECTROSCOPES

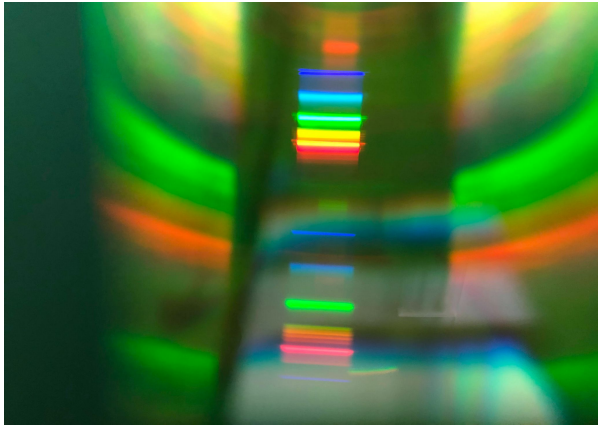


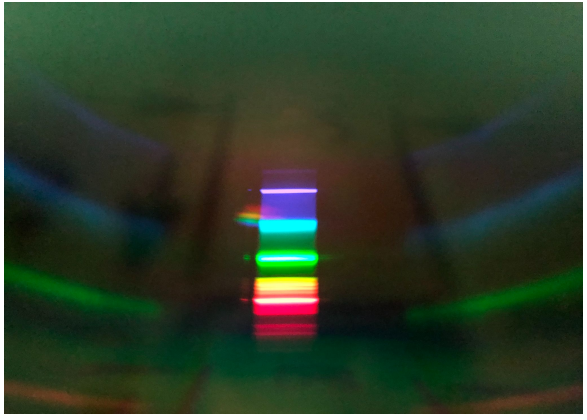


Some student images from the paper spectroscope



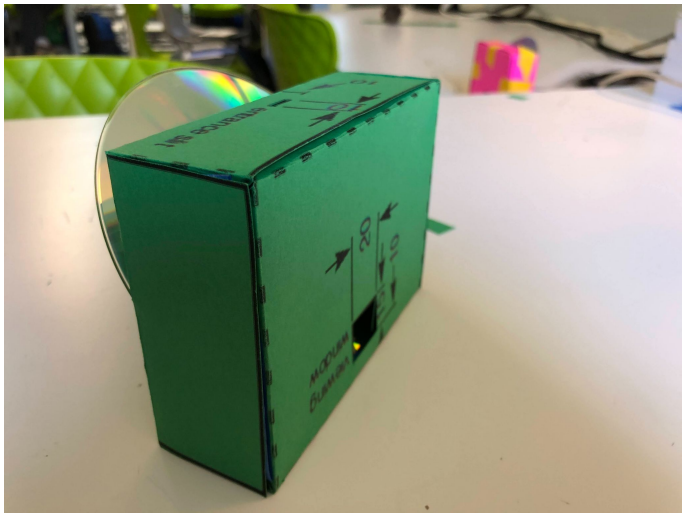






You can try it out

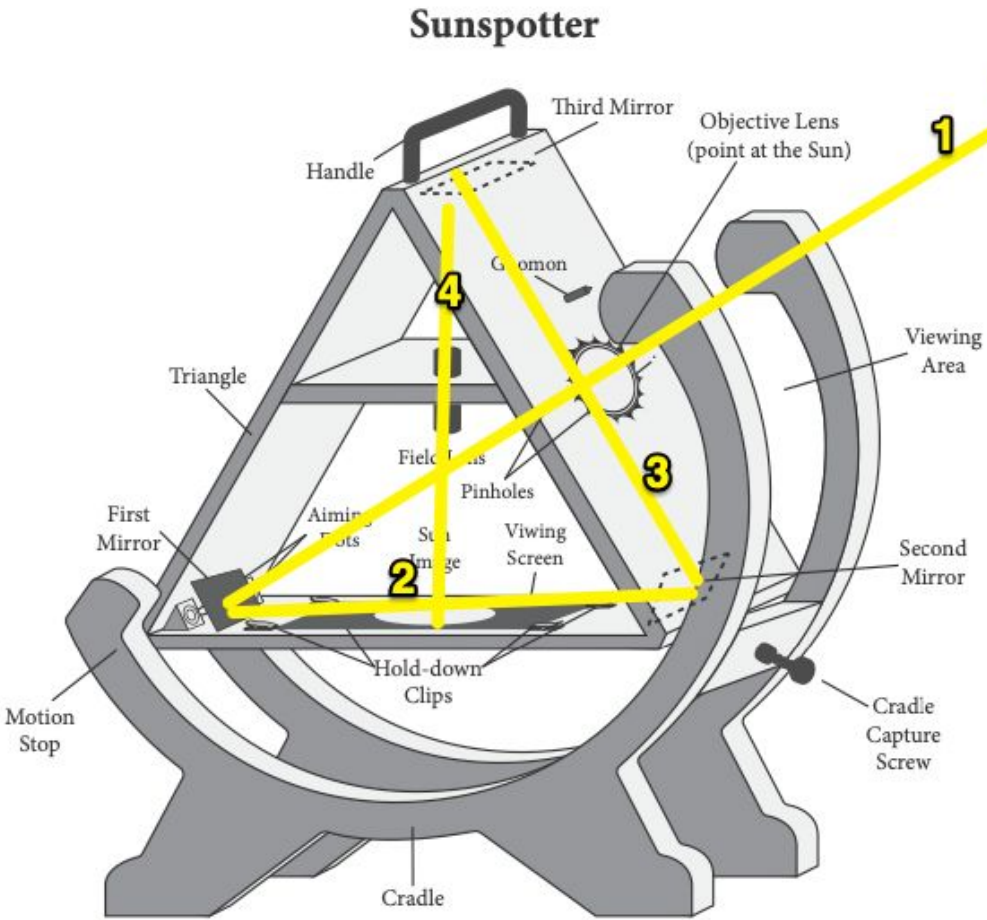
Ask a student to give you one to look through !!



Thursday
Day 4

Astronomer Mr. Tom Fields Visit - Solar Observations

- Use Sun Spotter to see Sunspots. Compare to the Solar & Heliospheric Observatory images from today!
- See the surface of the Sun using the Lunt Telescope
- Look at the absorption spectra of the Sun using the Shelyak spectrograph
- Do you see any Solar Flares or Prominences?
- Each team will sketch the Sun and Sunspots. This will take some practice. We will help!
- Measure Diameter of the Sun using the Sun Spotter
- Measure how big the Sunspots are



<u>To do Outside:</u>
Sketch sunspots one at a time after re-aligning each time.

Then re-align and quickly plot 3 points on the circumference of the sun's image

Then construct 2 perpendicular lines to draw a circle through those 3 points. You have now sketched the Sun!

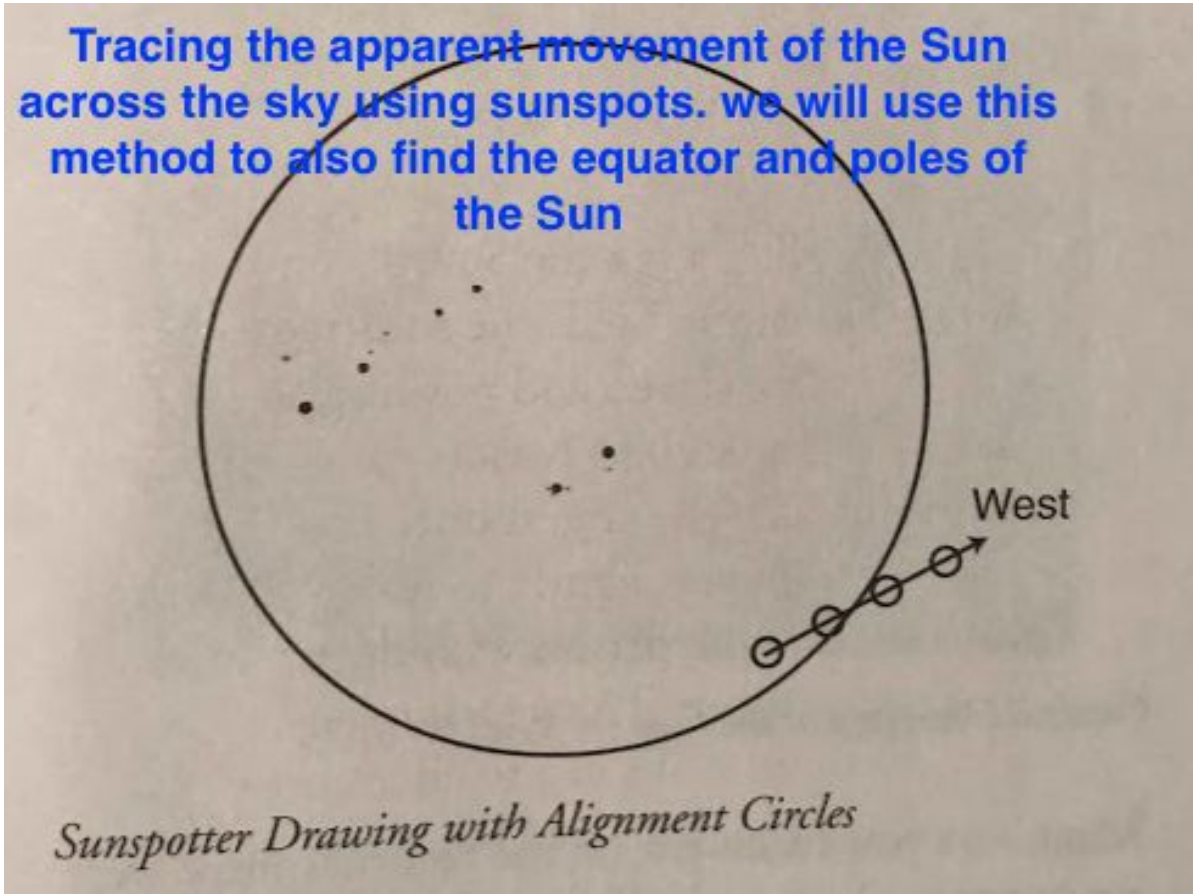
Record the transit time of the sun across its own diameter in seconds

Record the direction of movement of the sun using a sunspot at least 4 times after realigning the template. That will be moving west.

<u>Later in the classroom:</u>
Calculate the diameter of the Sun!

<u>Link for Sunspotter Manual</u>

Trace the apparent movement of the sun across the sky

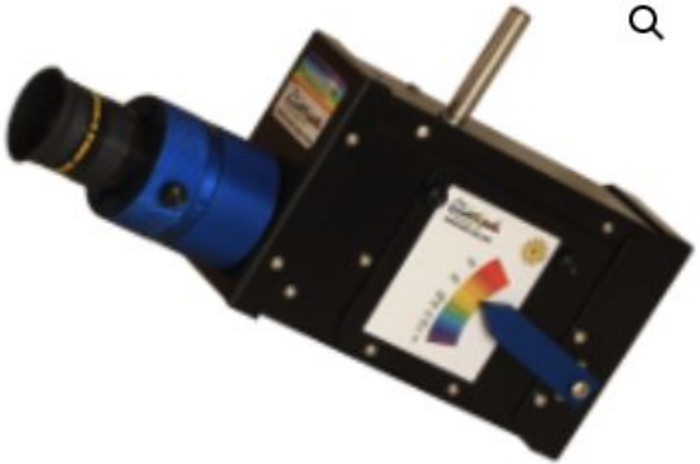


See the surface of the Sun through the Lunt Telescope!

Did you notice any solar flares or prominences?

How big do you think they are?

See the Hi-Res absorption spectrum of the sun! Telescope!



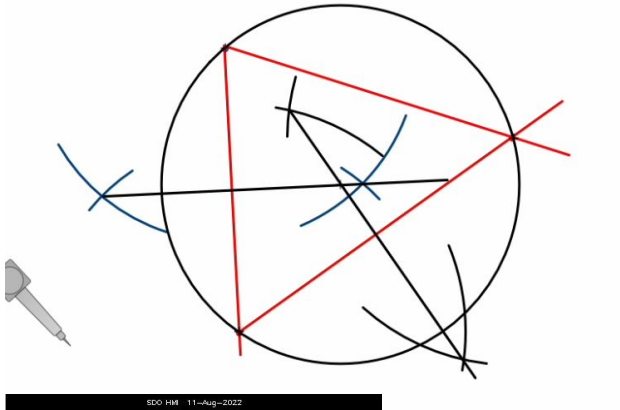
We will use the Shelyak Spectrograph

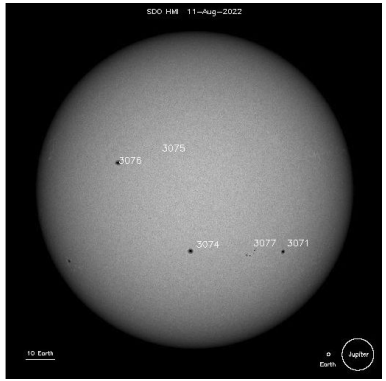
Do you see the absorption lines of the various elements?

What did you find interesting?

What can you conclude about the what we are all made of??

Construct the sun with a compass constructing perpendicular bisectors

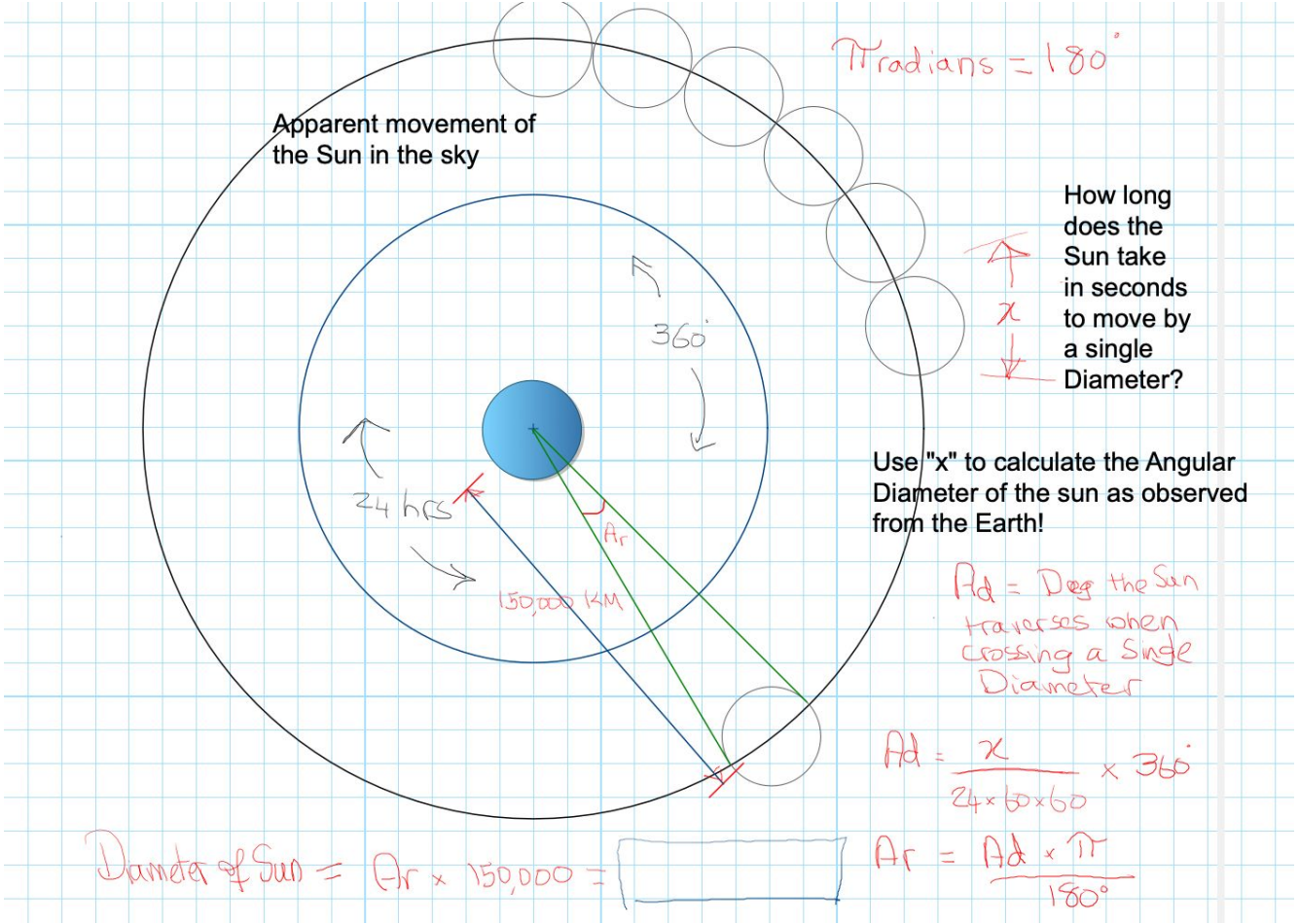




Watch this video if you have question about constructing a circle with 3 points!

Calculate the diameter of the sun using the time it takes for the sun to transit one full diameter. See next page

Compare your sunspots with the heliospheric observations of the SOHO satellite from today!



Calculating the Diameter of the Sun!

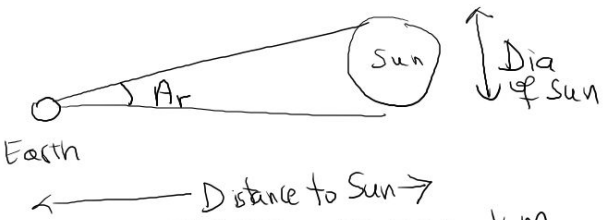
Which team is going to come closest to the actual value of: 1.3927 Million KM ??

Convert Angular Diameter of the Sun to KM!

Angular Diameter of the Sun = A_d (You just calculated this!)

Convert Degrees to Radians (π radians = 180°)

$$A_r = \frac{A_d \times \pi}{180^\circ}$$



Dia of Sun = $A_r \times 150{,}000{,}000$

= [ ] km

Calculate Angular Diameter of the Sun

Time taken by Sun to traverse its own Diameter: x seconds

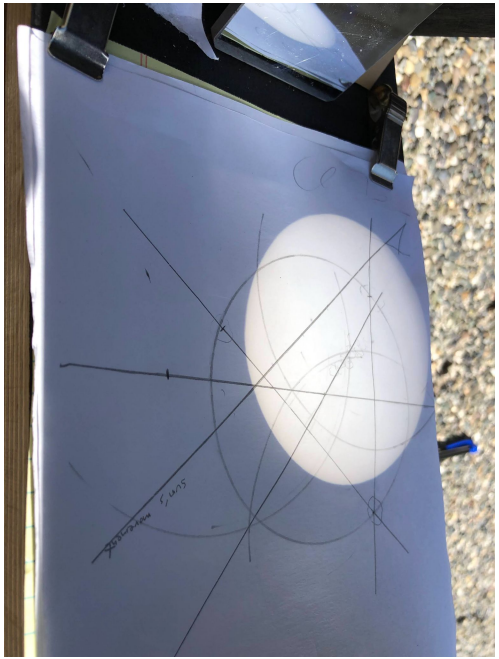
Time taken by Earth to rotate once: $t_d = 24 \times 60 \times 60$ seconds

$t_d = 86400$ seconds

No of degrees in a Circle $= 360^\circ$

No. of degrees Sun traverses when it moves 1-diameter $= \frac{x \times 360}{86400}$

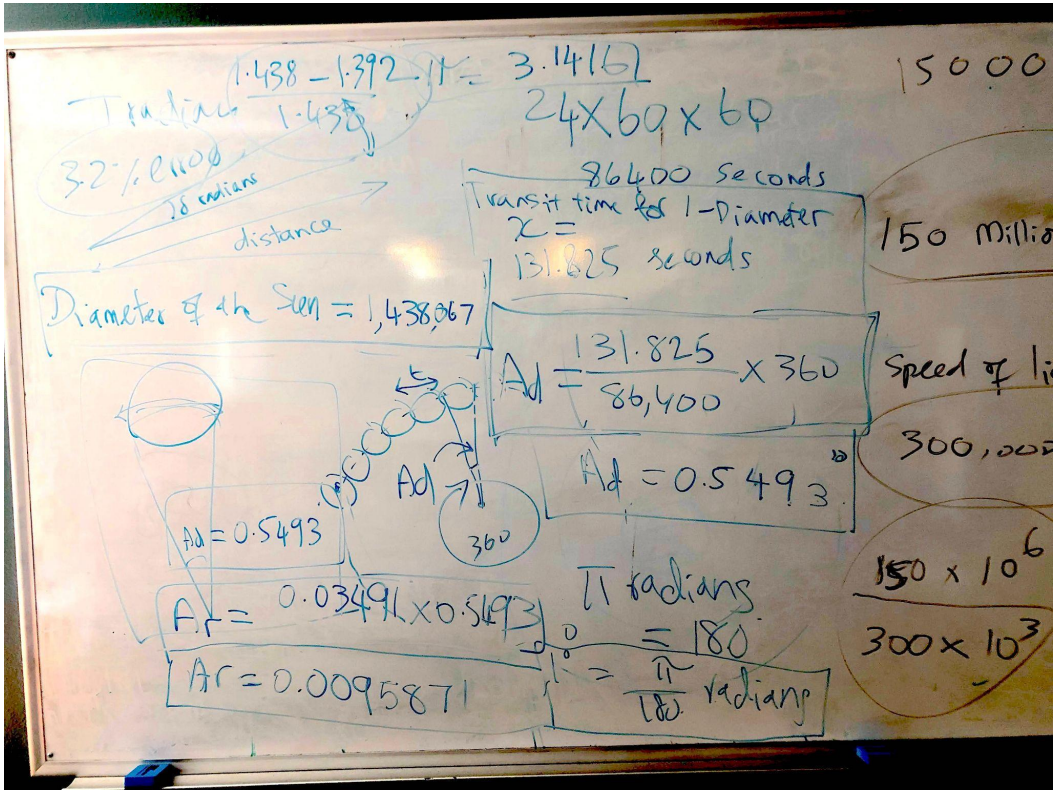
This is the Angular Diameter of the Sun



We measured the average transit time of the Sun to traverse one diameter to be:

X = 131.825 seconds

Calculations of the Diameter of the Sun



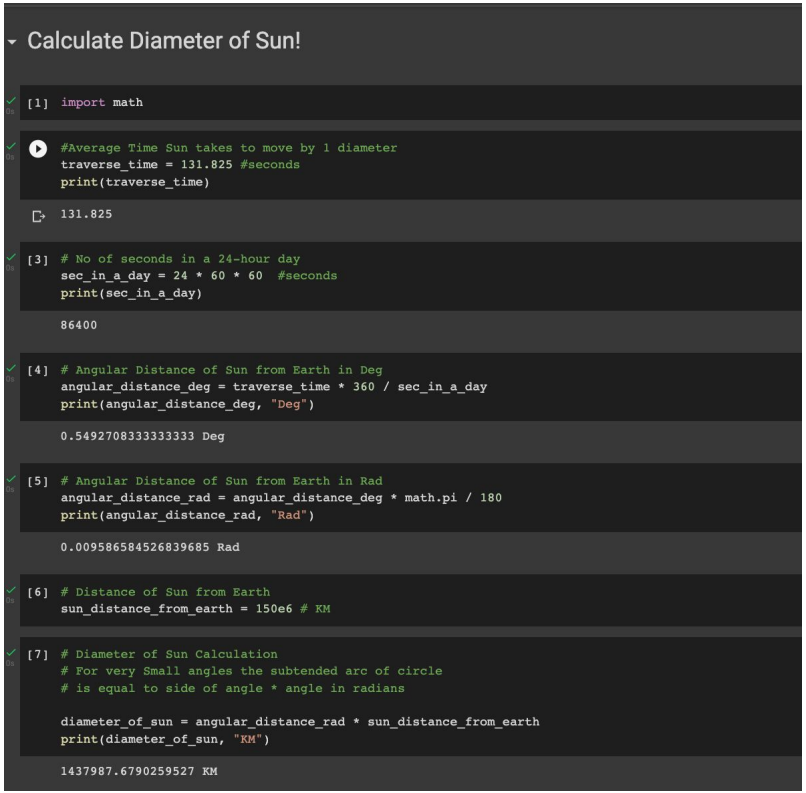
We found the Sun's diameter to be: 1,438,067 KM

The precise distance of the Sun is known to be: 1,392,684 KM

This represents an error of: +3.25% overestimate

This is an excellent result!!

Calculations of the Diameter of the Sun



Calculate Diameter of Sun!

```
[1] import math

#Average Time Sun takes to move by 1 diameter
traverse_time = 131.825 #seconds
print(traverse_time)
```

```
131.825
```

```
[3] # No of seconds in a 24-hour day
sec_in_a_day = 24 * 60 * 60  #seconds
print(sec_in_a_day)
```

```
86400
```

```
[4] # Angular Distance of Sun from Earth in Deg
angular_distance_deg = traverse_time * 360 / sec_in_a_day
print(angular_distance_deg, "Deg")
```

```
0.5492708333333333 Deg
```

```
[5] # Angular Distance of Sun from Earth in Rad
angular_distance_rad = angular_distance_deg * math.pi / 180
print(angular_distance_rad, "Rad")
```

```
0.009586584526839685 Rad
```

```
[6] # Distance of Sun from Earth
sun_distance_from_earth = 150e6 # KM
```

```
[7] # Diameter of Sun Calculation
# For very Small angles the subtended arc of circle
# is equal to side of angle * angle in radians

diameter_of_sun = angular_distance_rad * sun_distance_from_earth
print(diameter_of_sun, "KM")
```

```
1437987.6790259527 KM
```

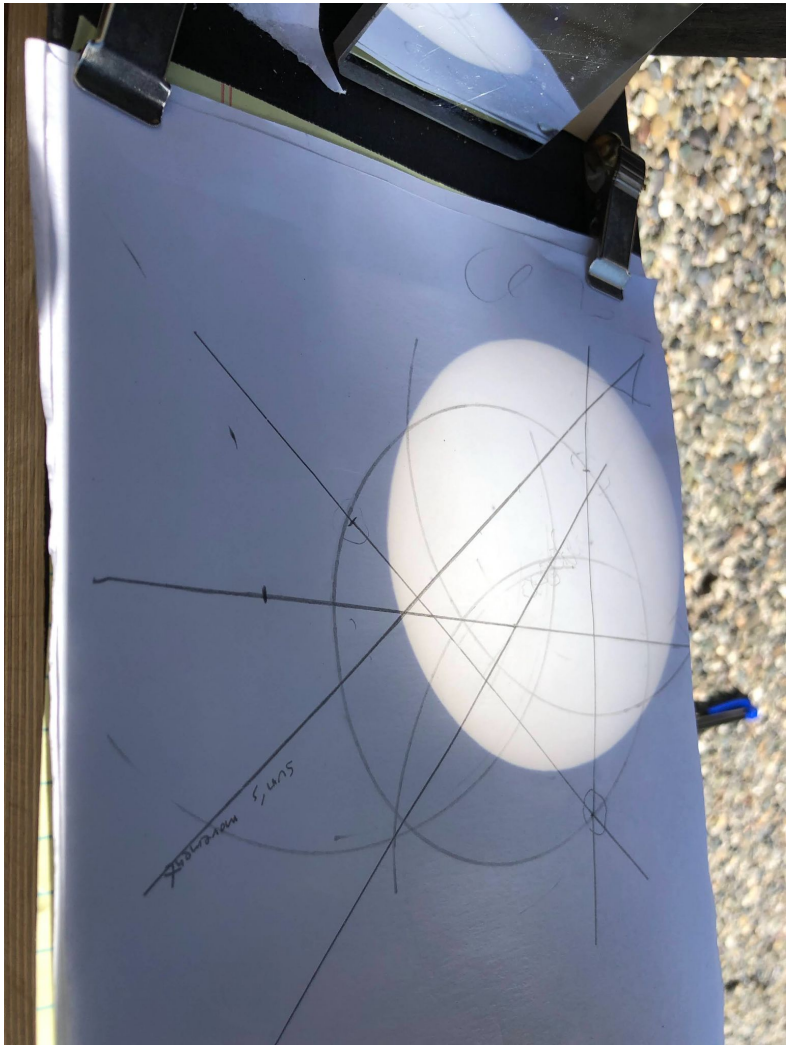
We found the Sun's diameter to be: 1,438,067 KM

The precise distance of the Sun is known to be: 1,392,684 KM

This represents an error of: +3.25% overestimate

This is an excellent result!!

Images from today's workshop



Images from today's workshop

Images from tonight's observing

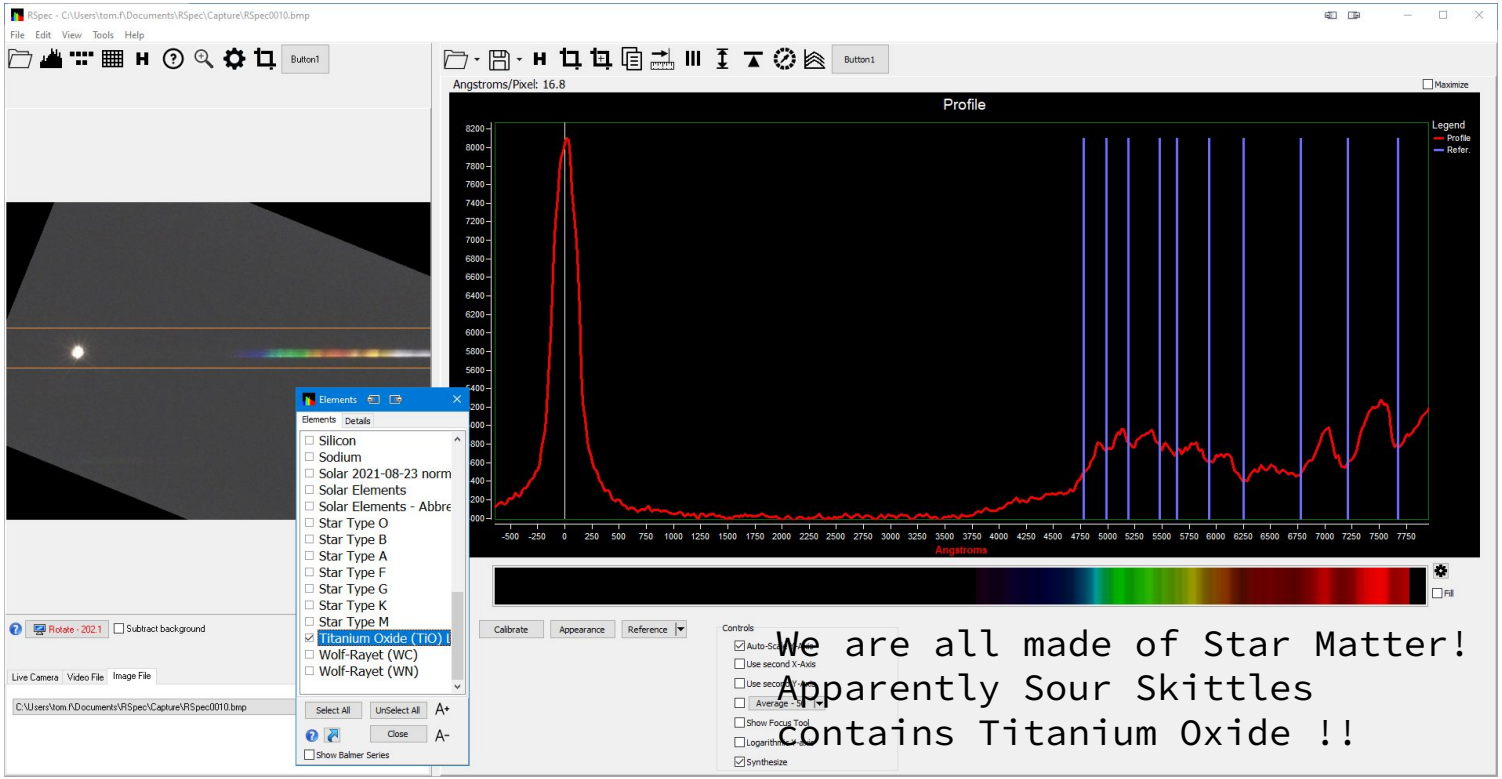
THANK YOU ALL FOR COMING!

SPECTRUM OF RASALGETHI - A RED GIANT STAR WITH A HELIUM HYDROGEN ENVELOPE AND A CARBON-OXYGEN CORE! YOU CAN SEE THE ABSORPTIONS LINES CLEARLY IN THE SPECTRUM BELOW!

DUMBBELL NEBULA - THE REMNANTS OF A DEAD STAR SHOW HYDRON (RED) AND OXYGEN GREENISH BLUE!

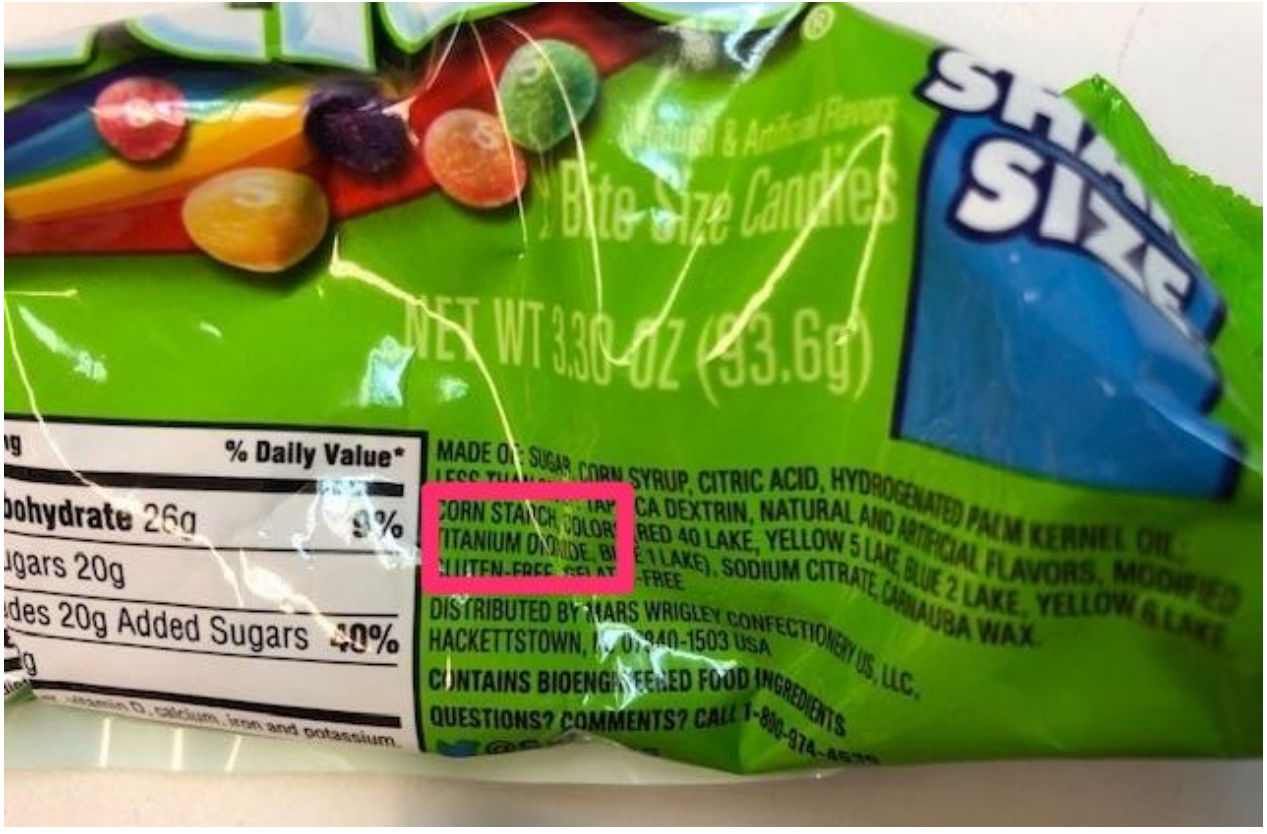
Analyzed spectra of absorption lines by Mr Tom Field!

We detected titanium oxide in this star - Rasalgethi!



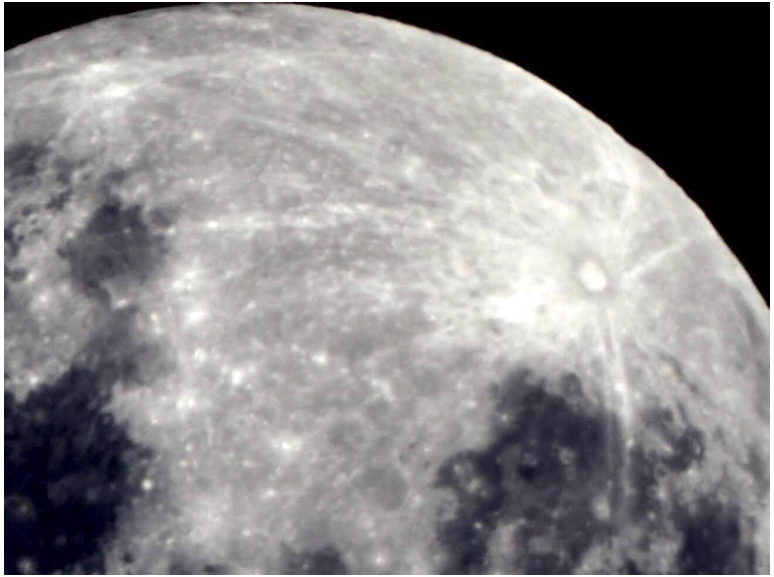
We are all made of Star Matter!
Apparently Sour Skittles
Contains Titanium Oxide !!

Titanium Dioxide is in Skittles!



IMAGES FROM TONIGHT'S OBSERVING

WE ALSO CAPTURED THE GLOBULAR CLUSTER M92 AND THE ALMOST FULL MOON. CRATER TYCHO IS CLEARLY VISIBLE



Week 2
Citizen Science
Workshop

Materials Needed for Week 2

Python for Measuring the Diameter of the Sun & an Atom workshops
Team 1: http://rypi53.ddns.net:8888
Team 2: http://rypi54.ddns.net:8888

Spectroscopy workshop
Team 1: http://bupi1.ddns.net:8888
Team 2: http://bupi2.ddns.net:8888
Team 3: http://bupi4.ddns.net:8888

Breadboard Electronics and Stop Motion workshops:
Team 1: http://rypi50.ddns.net:8888
Team 2: http://rypi51.ddns.net:8888
Team 3: http://rypi52.ddns.net:8888

Time Lapse photography workshop:
Team 1: http://rypi55.ddns.net:8888
Team 2: http://rypi56.ddns.net:8888

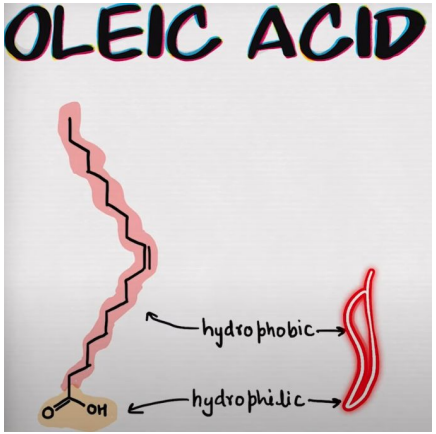
Attachments you will need:
1. rdslibv1.ipynb: Python Notebook for Library Functions in Python
2. rdsprojv1.ipynb: Python Notebook for workshops
3. raspberry_pi_assignments: This information
4. The Galton Board Spreadsheet
5. Daily Slides Presentation

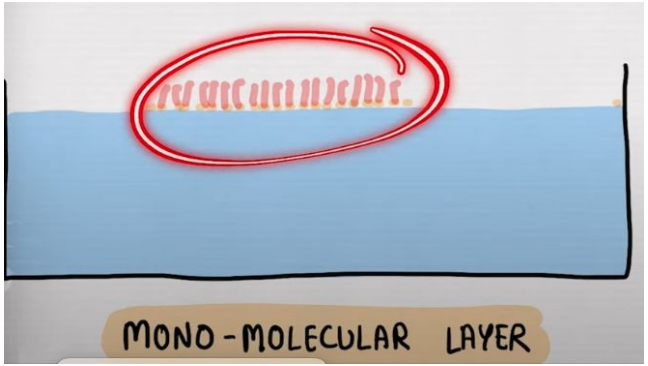
Monday
Day 5
Atom diameter
Spectral lines

Todays labs

1. Measure the diameter of an atom
2. Compare to scientific data published!
3. Build a spectroscope using a raspberry pi in a wooden box
4. Measure spectral emission lines of various elements!
5. Compare to National Institute of Standards data (NIST)

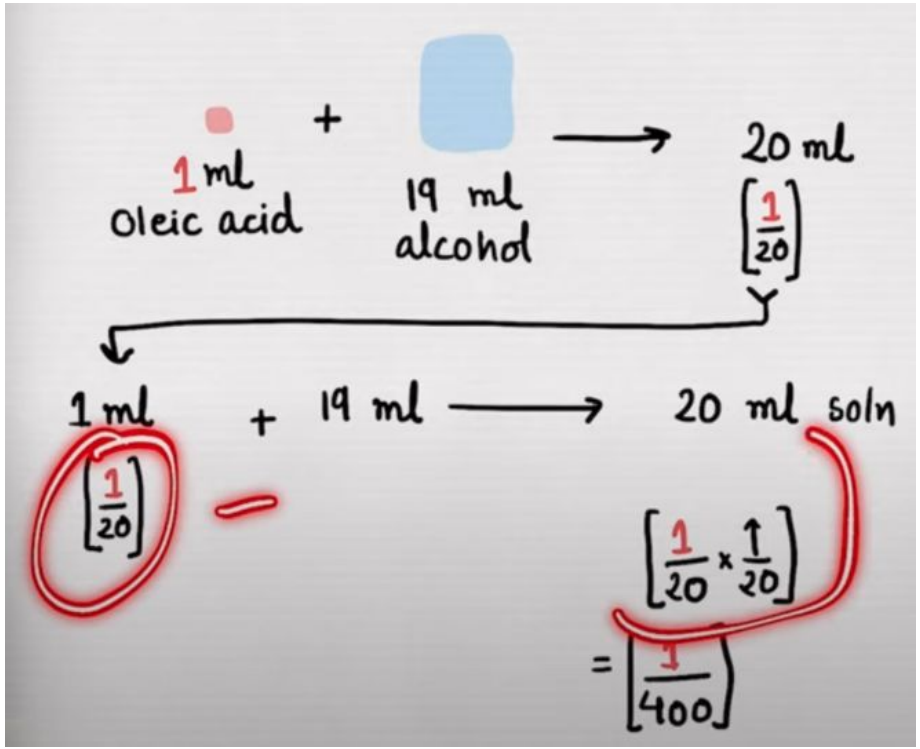
Process to MEASURE THE Diameter of an Atom using oleic acid

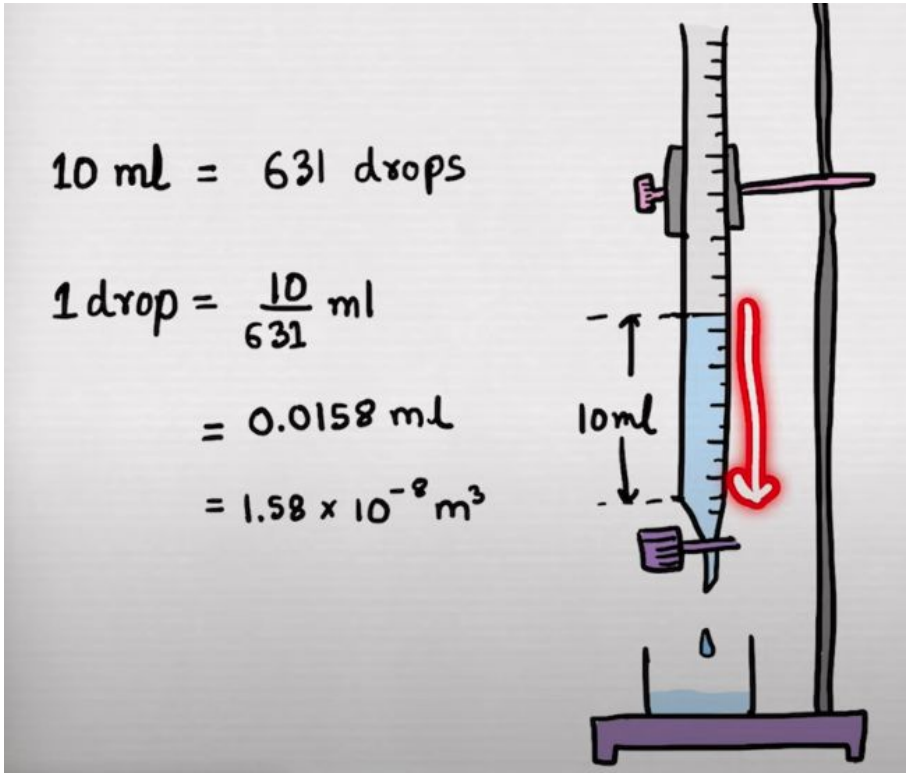




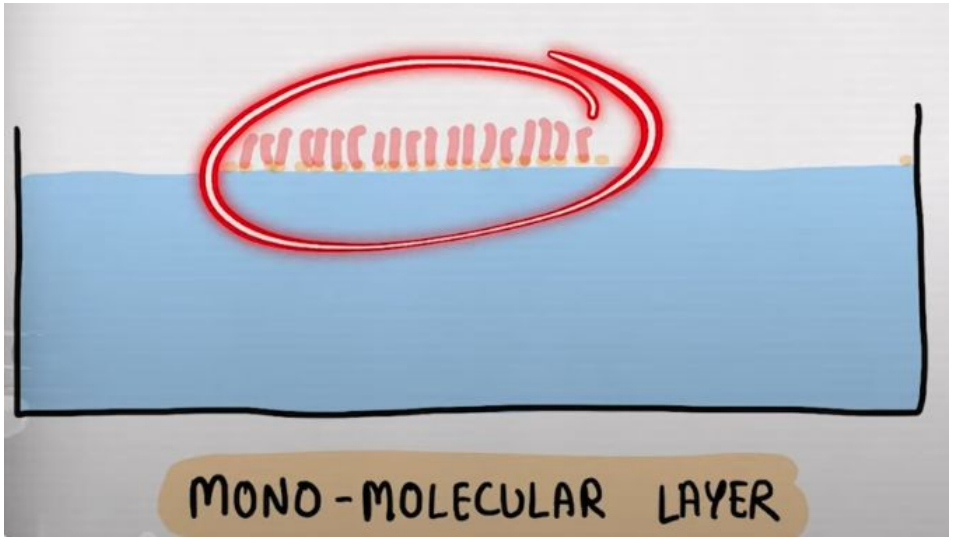
- Oleic acid is a simple molecule with hydrophilic and hydrophobic parts!
- Prepare a 1/400 solution of Oleic acid in alcohol
- Calculate the volume of Oleic acid in droplet of the this solution
- Create a mono-molecular layer of this solution floating on water
- Measure its diameter and calculate its thickness knowing the volume of the Oleic acid in the droplet
- The thickness is the diameter of an atom!!

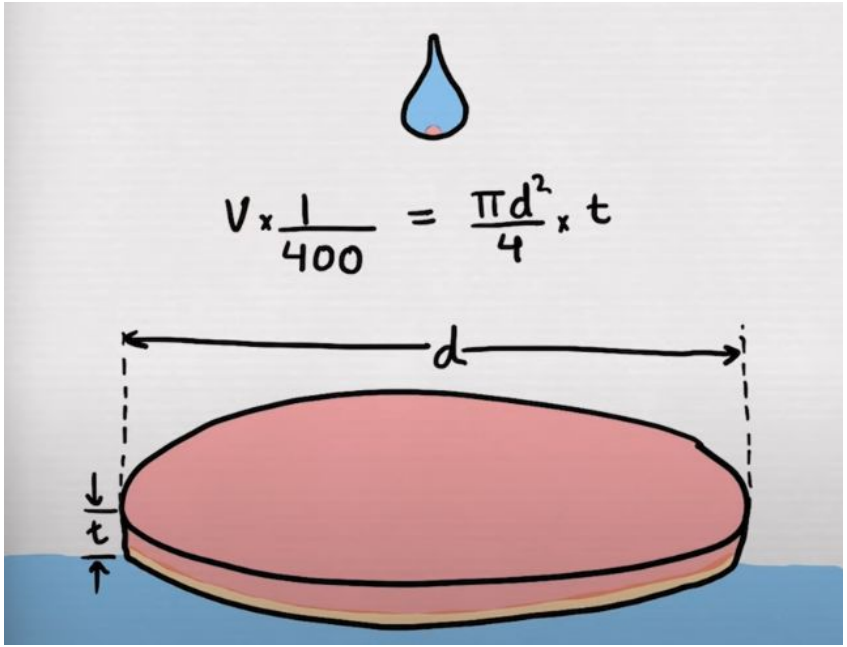
Process to MEASURE THE Diameter of an Atom



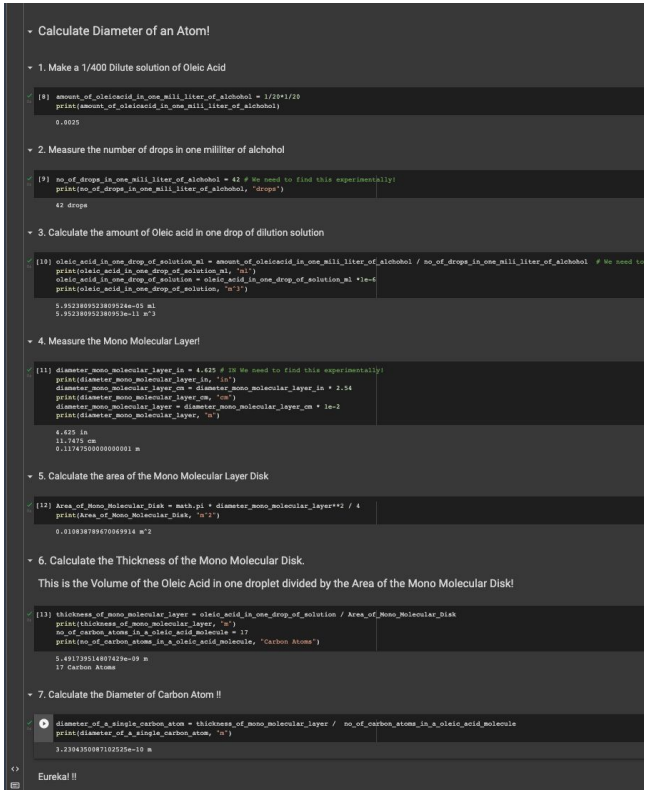


Process to MEASURE THE Diameter of an Atom using OLEIC ACID





Calculation details - Measuring the diameter of an atom!



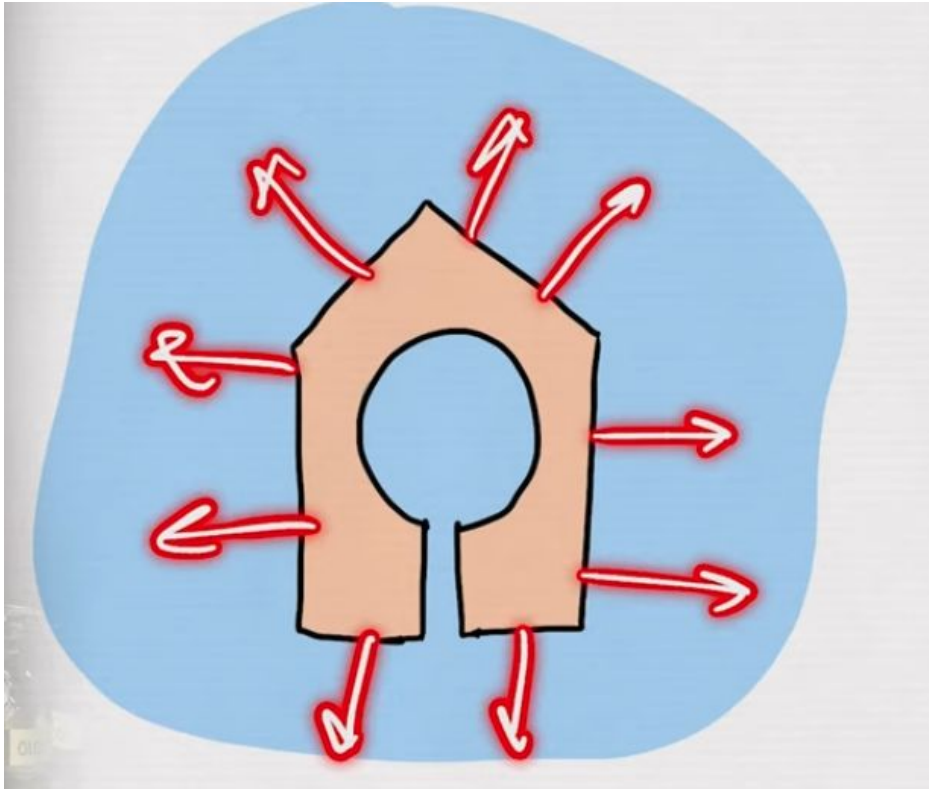
We calculated the diameter of the Carbon atom to be:
3.23 X 10^-10 m

Earlier we calculated the diameter of the Sun to be:
1.43 X 10^9 m !!!

This is how many orders of magnitude difference?

Where is the human being on this scale?

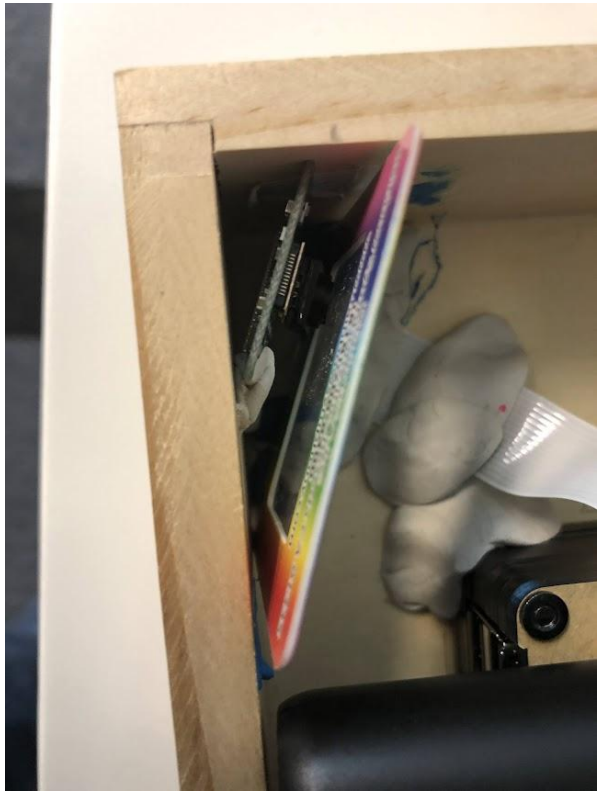
Surface tension boat using oleic acid!



Wooden Spectroscope & Emission Lines

- Build & Calibrate the Wooden Box Spectroscope
- Obtain images emission spectra of various elements - Hydrogen, Helium, Mercury, Neon
- Chart using Jupyter Notebooks
- Compare to NIST standards
- Spectral chart of Elements

Build the wooden raspberry pi spectroscope



Jupyter Notebook for Spectra

Creating the Spectrometer Camera Object

```
# STEP 2. CREATE THE CAMERA OBJECT
#         CAPTURE THE RAW SPECTRUM IMAGE
#         THIS WILL BE EXAMINED FOR ANY ADJUSTMENTS NEEDED
#         FOR EXAMPLE IMAGE BRIGHTNESS LIGHT LEAKAGE ETC
#         DISPLAY CAPTURED IMAGE
```

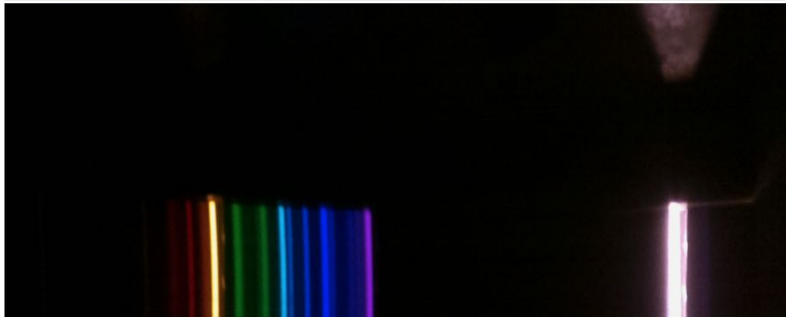
```
#         Get camera object. Note that this can only be executed ONCE per run
#         YOU SHOULD NOT RUN IT AGAIN UNLESS THE CAMERA IS CLOSED WHICH
#         THIS STATEMENT IS AT THE VERY BOTTOM OF THIS FILE
try:
    camera = picamera.PiCamera()
except:
    print("Exception in opening camera object")
    print("Closing and Recreating Camera Object")
    camera.close()
    camera = picamera.PiCamera()
finally:
    print("Camera object created")
```

```
Camera object created
```

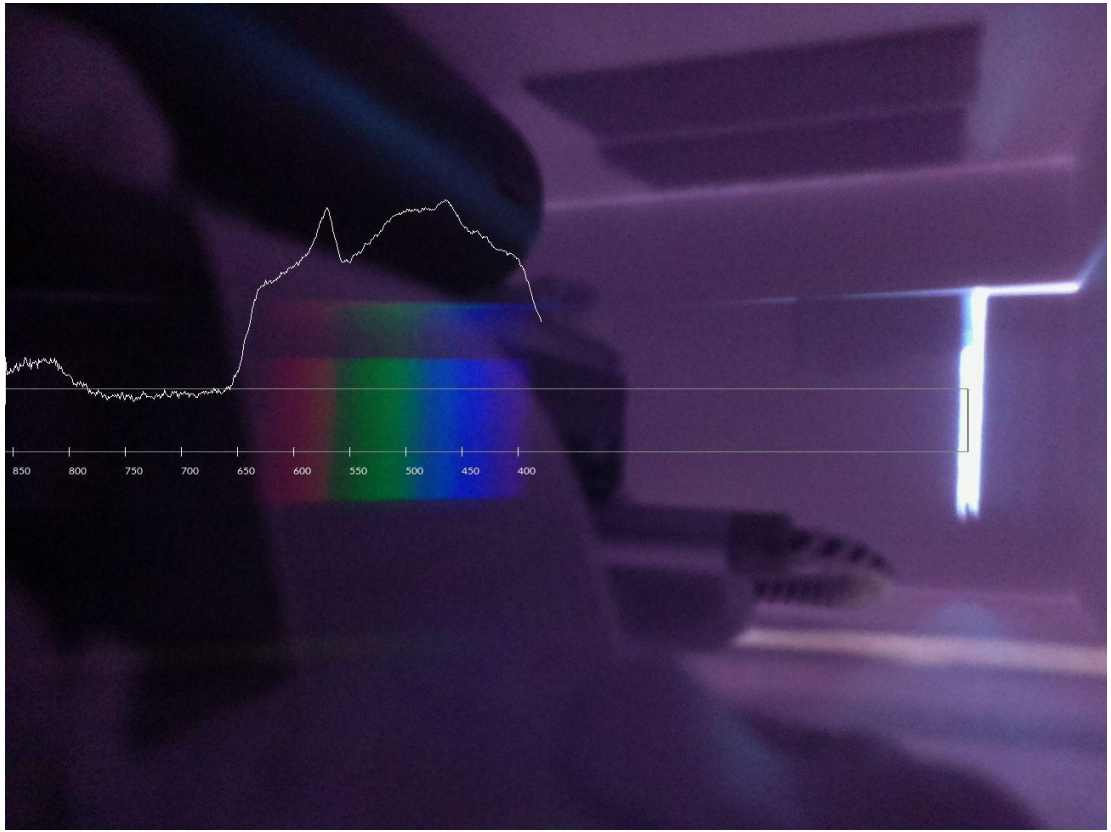
```
#          Set the shutter speed of the camera.
#          Use 100000 for a medium bright spectrum
#shutter = 5000
camera.shutter_speed = shutter
#          flip the image laterally as my analysis software reads with slit on the right!
camera.hflip = True
#          capture image with a predetermined size suitable for pixel counting analysis
raw_jpg_filename = raw_filename + ".jpg"
camera.capture(raw_jpg_filename, resize=(1296, 972))
#camera.capture(raw_jpg_filename, resize=(800, 600))
```

Obtaining the Raw Image of the Spectrum

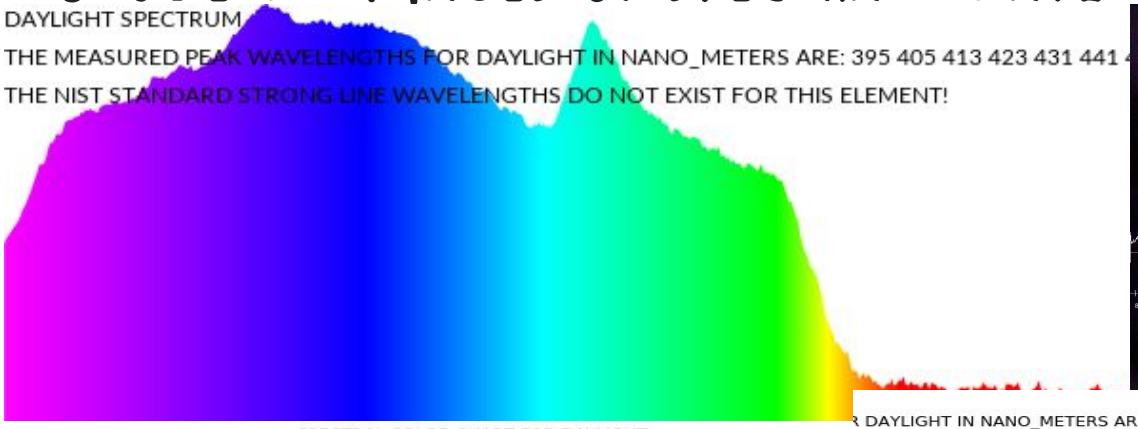
```
#       view image and apply putty or tape inside spectroscope to prevent light leakage
#       remember - image is flipped laterally from left right!
display(Image(raw_jpg_filename))
bdslibv2.display_bds_params(name,desc,shutter,slit_topadj,slit_botadj,spectrum_angle,wavelength_factor,samp_th,wlen_th)
```

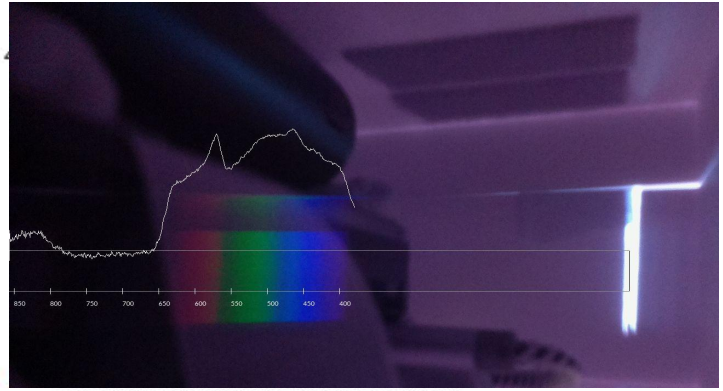


Student images of spectra - Daylight



Student images of spectra - Daylight

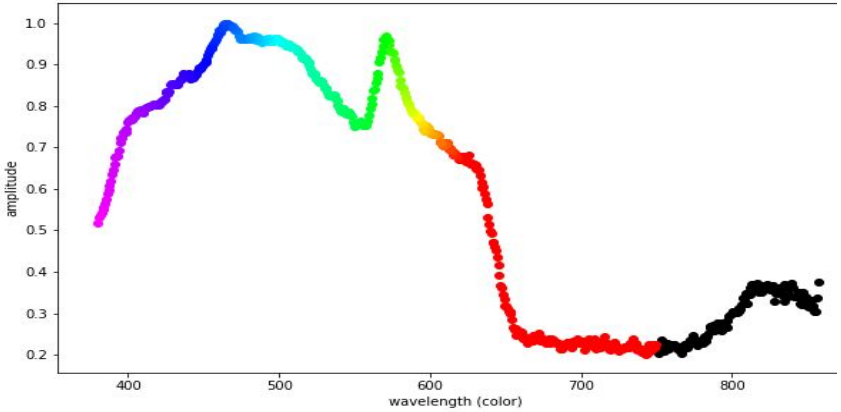




SPECTRAL COLOR CHART FOR DAYLIGHT

AYLIGHT IN NANO_METERS ARE: 395 405 413 423 431 441 454 466 483 492 503 517 527 536 545 553

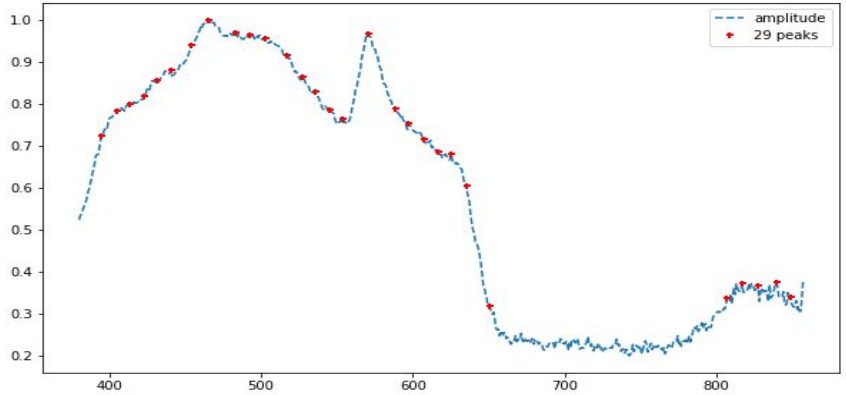
THE NIST STANDARD STRONG LINE WAVELENGTHS DO NOT EXIST FOR THIS ELEMENT!



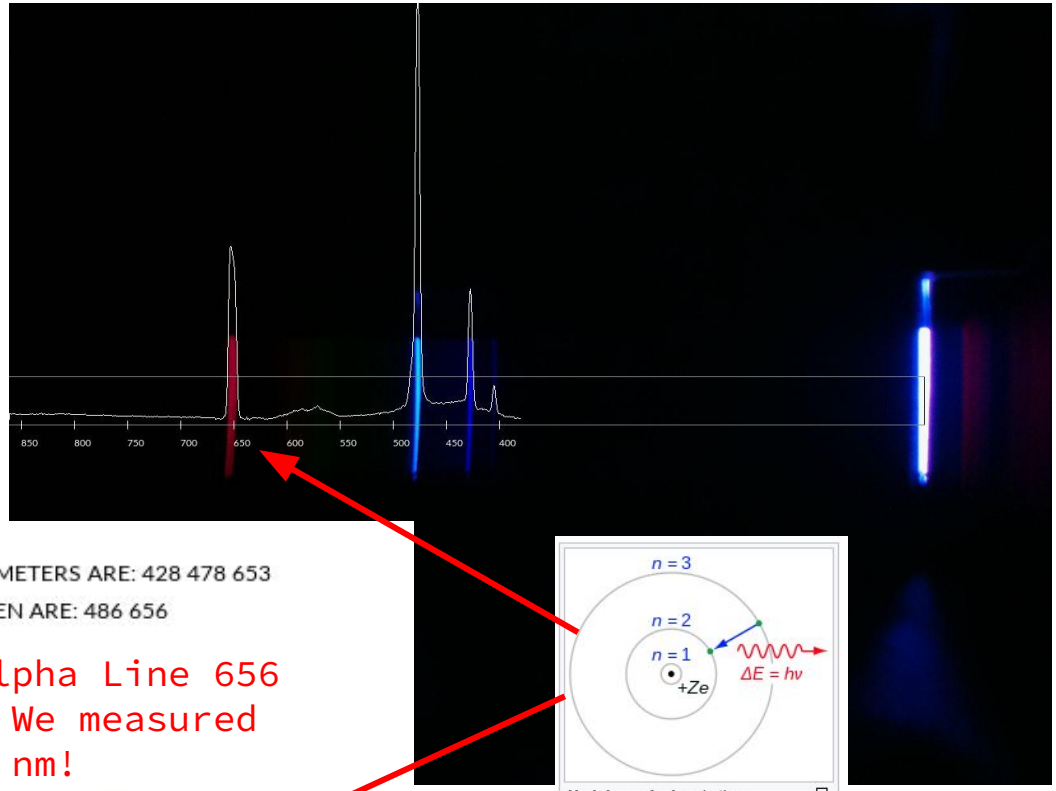
SPECTRAL PEAK WAVELENGTHS FOR DAYLIGHT

R DAYLIGHT IN NANO_METERS ARE: 395 405 413 423 431 441 454 466 483 492 503 517 527 536 545 553 571 588 597

THE NIST STANDARD STRONG LINE WAVELENGTHS DO NOT EXIST FOR THIS ELEMENT!



Student images of spectra - Hydrogen Gas Tube

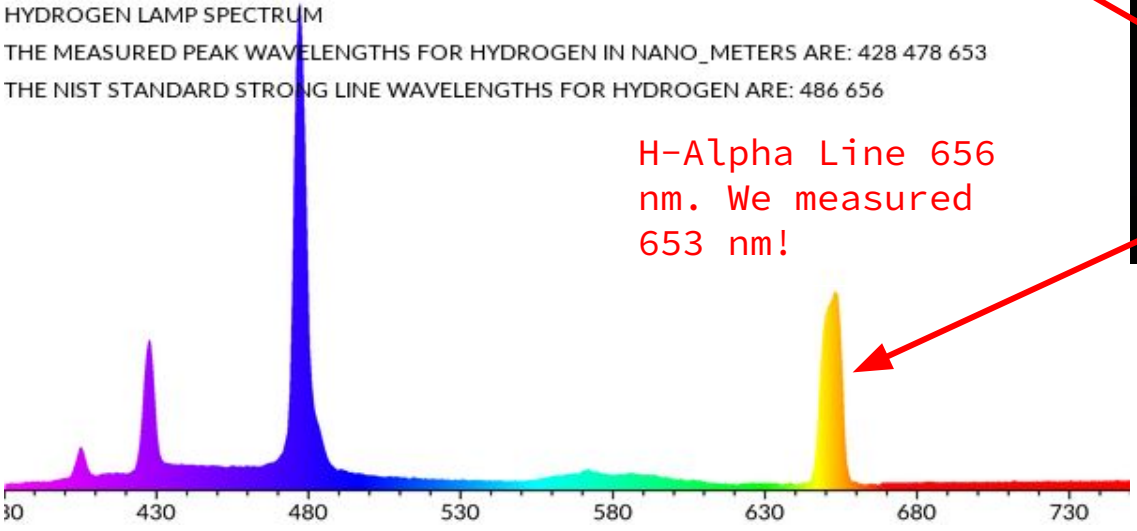


HYDROGEN LAMP SPECTRUM

THE MEASURED PEAK WAVELENGTHS FOR HYDROGEN IN NANO_METERS ARE: 428 478 653

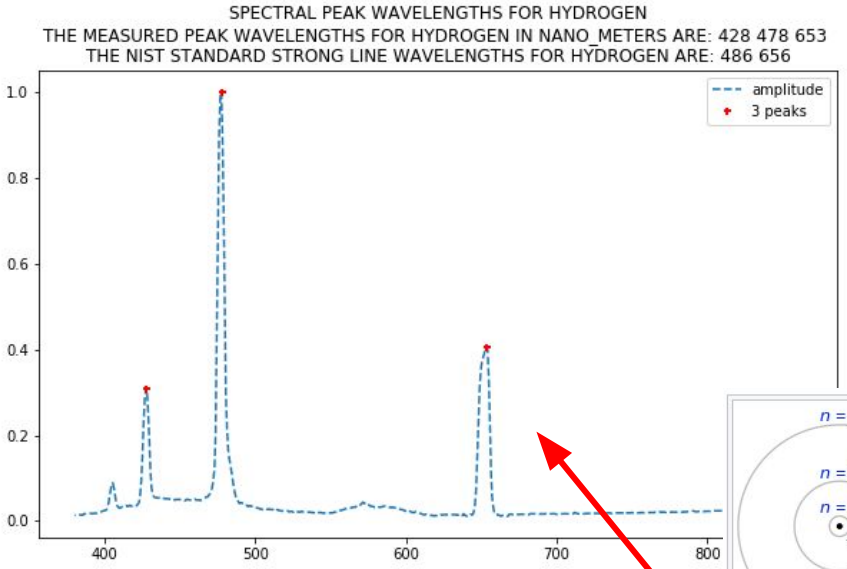
THE NIST STANDARD STRONG LINE WAVELENGTHS FOR HYDROGEN ARE: 486 656

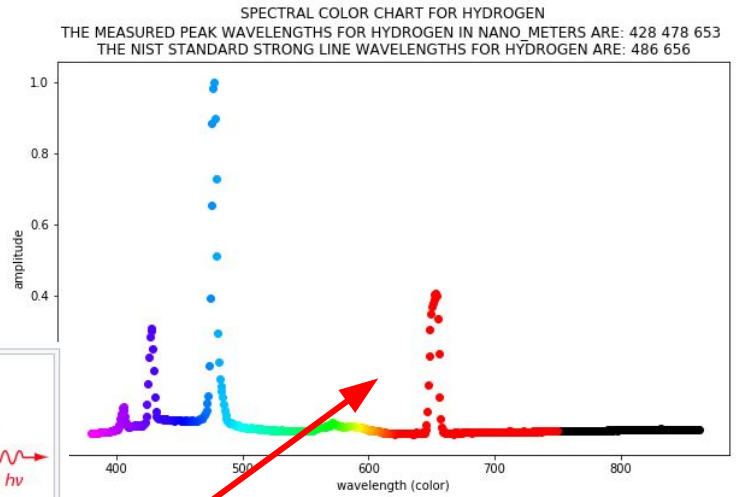
H-Alpha Line 656 nm. We measured 653 nm!

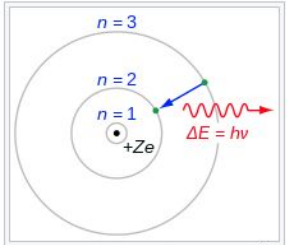


H-alpha emission: in the simplified **Rutherford Bohr model** of the hydrogen atom, the Balmer lines result from an electron jump to the second energy level closest to the nucleus from those levels more distant. The $3 \to 2$ transition depicted here produces an H-alpha photon, and the first line of the Balmer series. For hydrogen ($Z = 1$) this transition results in a photon of wavelength 656 nm (red).

Student images of spectra - Hydrogen Gas Tube



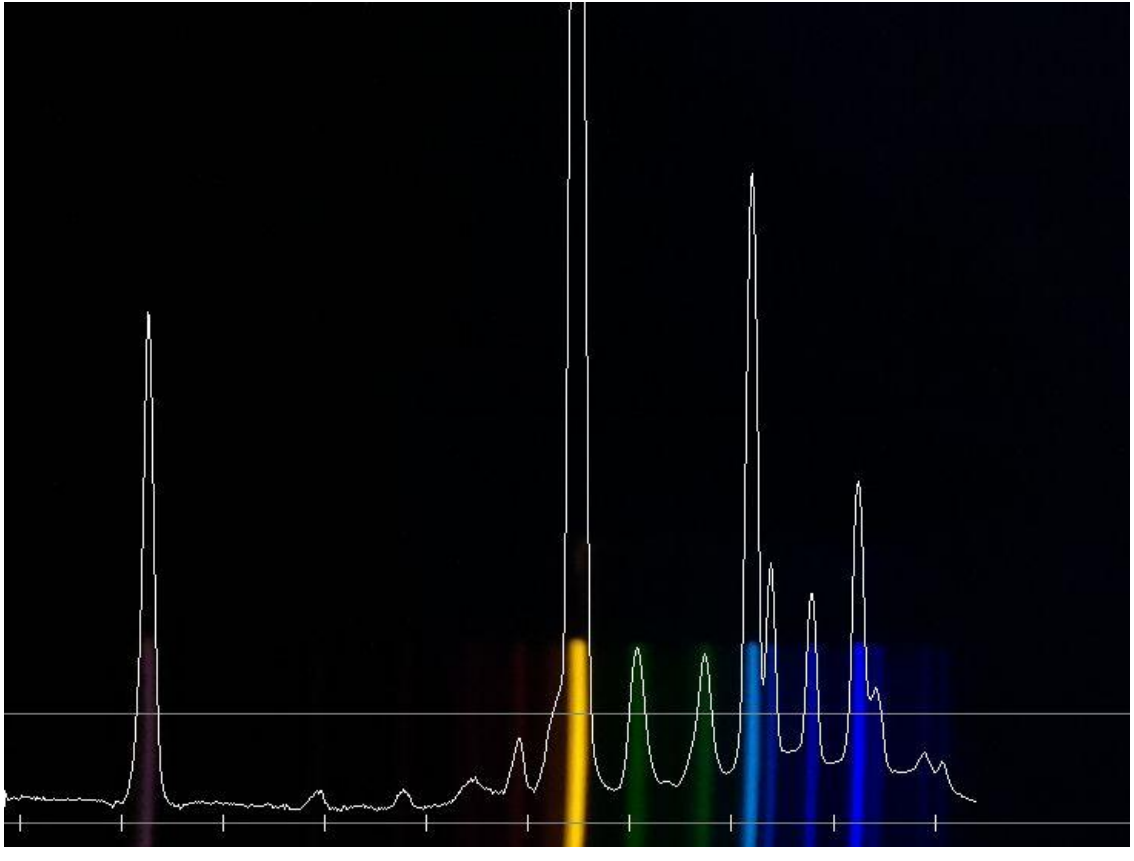




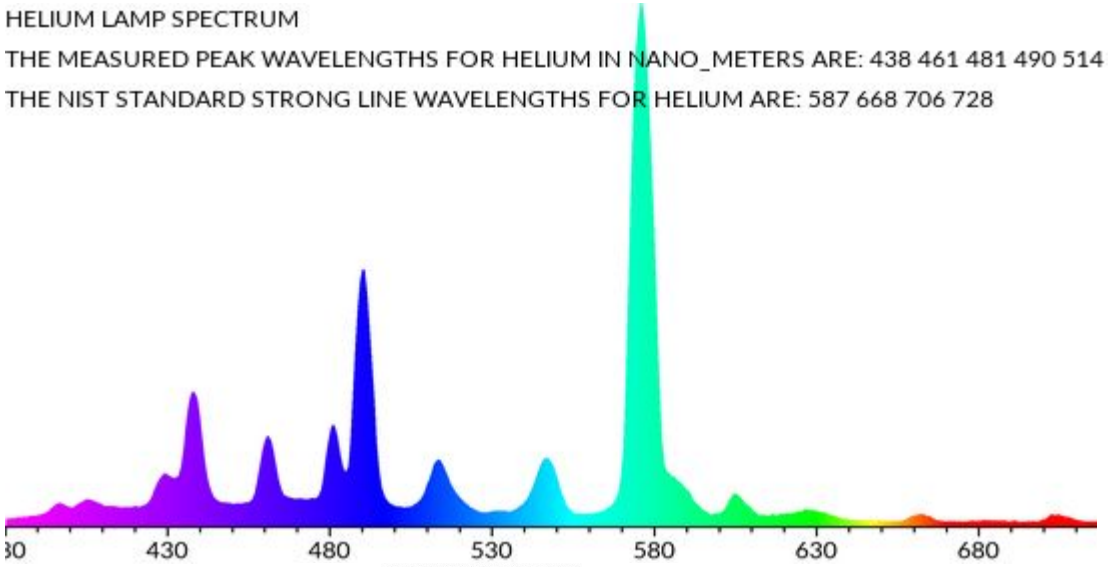
H-alpha emission: in the simplified **Rutherford Bohr model** of the hydrogen atom, the Balmer lines result from an electron jump to the second energy level closest to the nucleus from those levels more distant. The $3 \to 2$ transition depicted here produces an H-alpha photon, and the first line of the Balmer series. For hydrogen ($Z = 1$) this transition results in a photon of wavelength 656 nm (red).

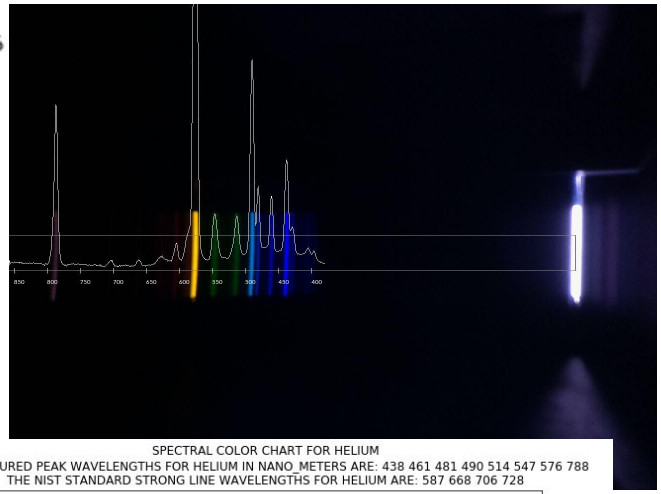
Hydrogen-Alpha emission line when an electron jumps from orbit 3 to 2! It has an exact wavelength of 656.2 nm. We measured 653 nm!

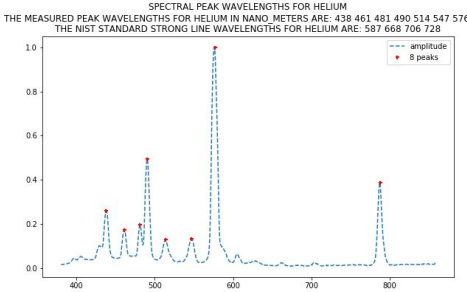
Student images of spectra - Helium Gas Tube

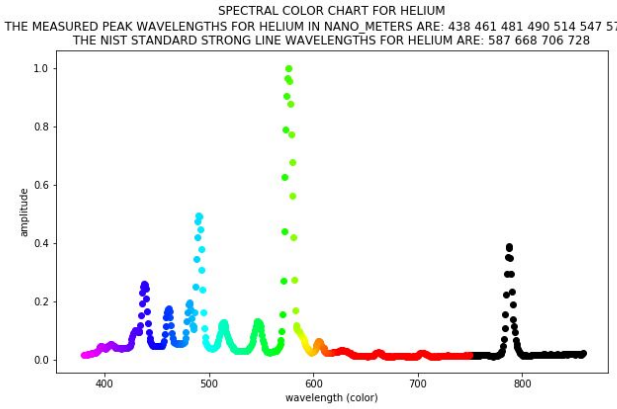


Student images of spectra - Helium Gas Tube

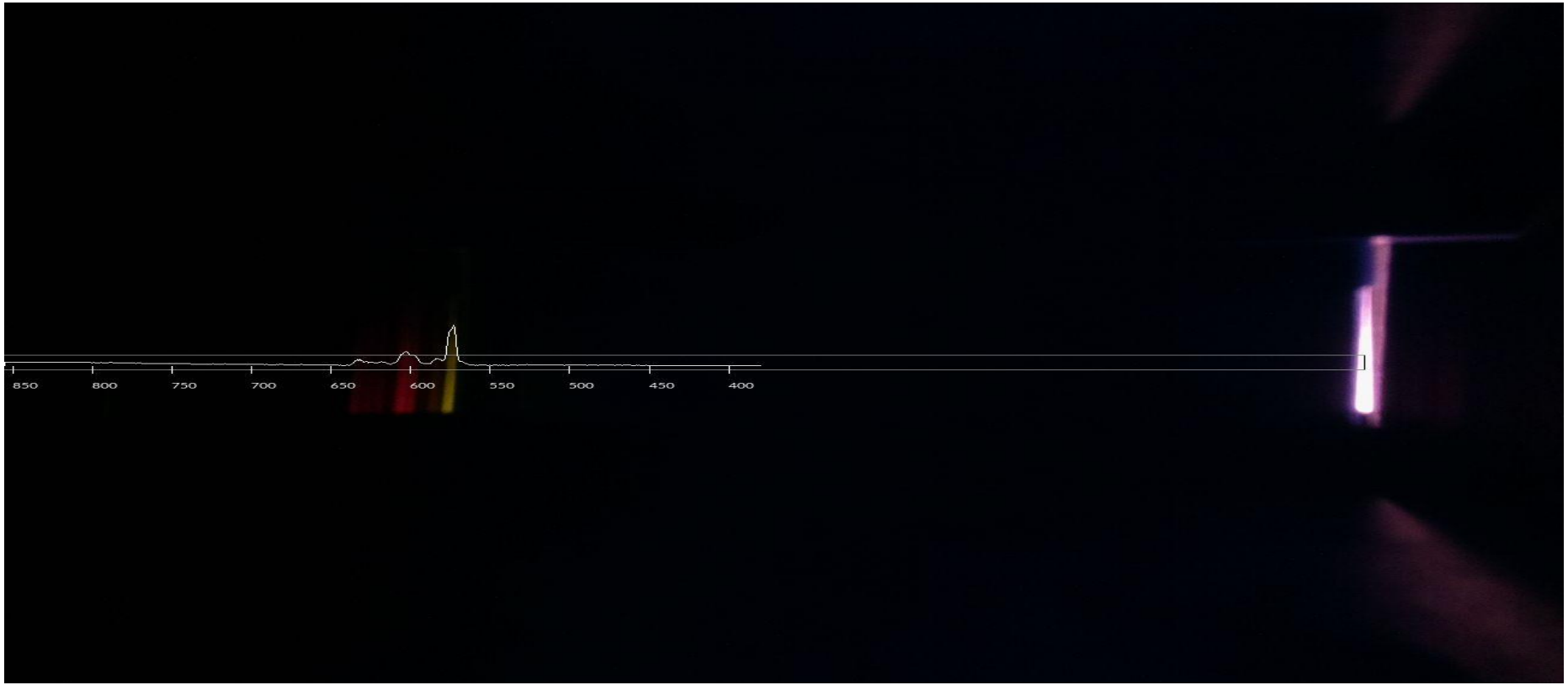








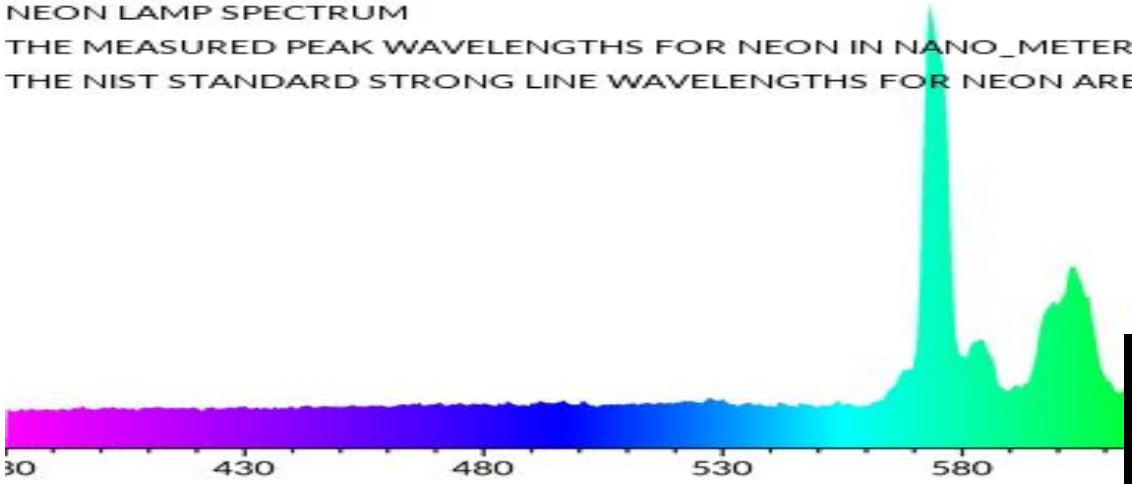
Student images of spectra - Neon Gas Tube

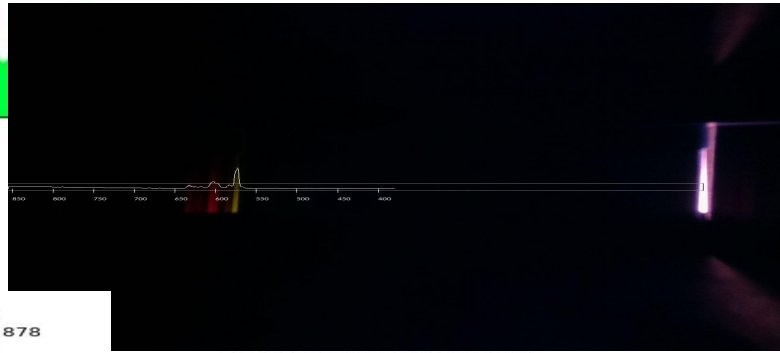


NEON LAMP SPECTRUM

THE MEASURED PEAK WAVELENGTHS FOR NEON IN NANO_METERS ARE: 573 584 603 619 634

THE NIST STANDARD STRONG LINE WAVELENGTHS FOR NEON ARE: 585 607 615 626 640 837 865 878

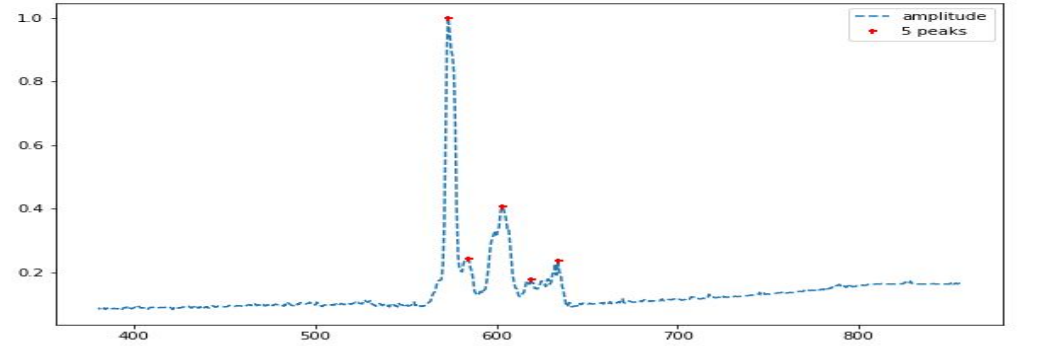




SPECTRAL PEAK WAVELENGTHS FOR NEON

THE MEASURED PEAK WAVELENGTHS FOR NEON IN NANO_METERS ARE: 573 584 603 619 634

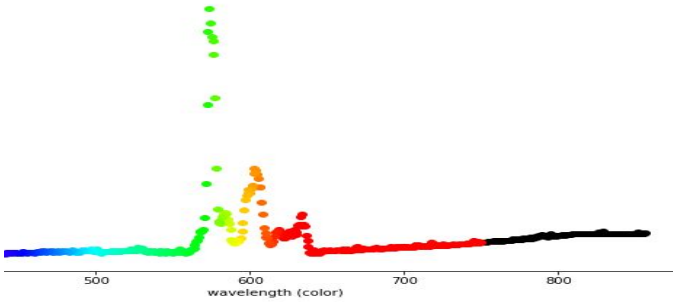
THE NIST STANDARD STRONG LINE WAVELENGTHS FOR NEON ARE: 585 607 615 626 640 837 865 878

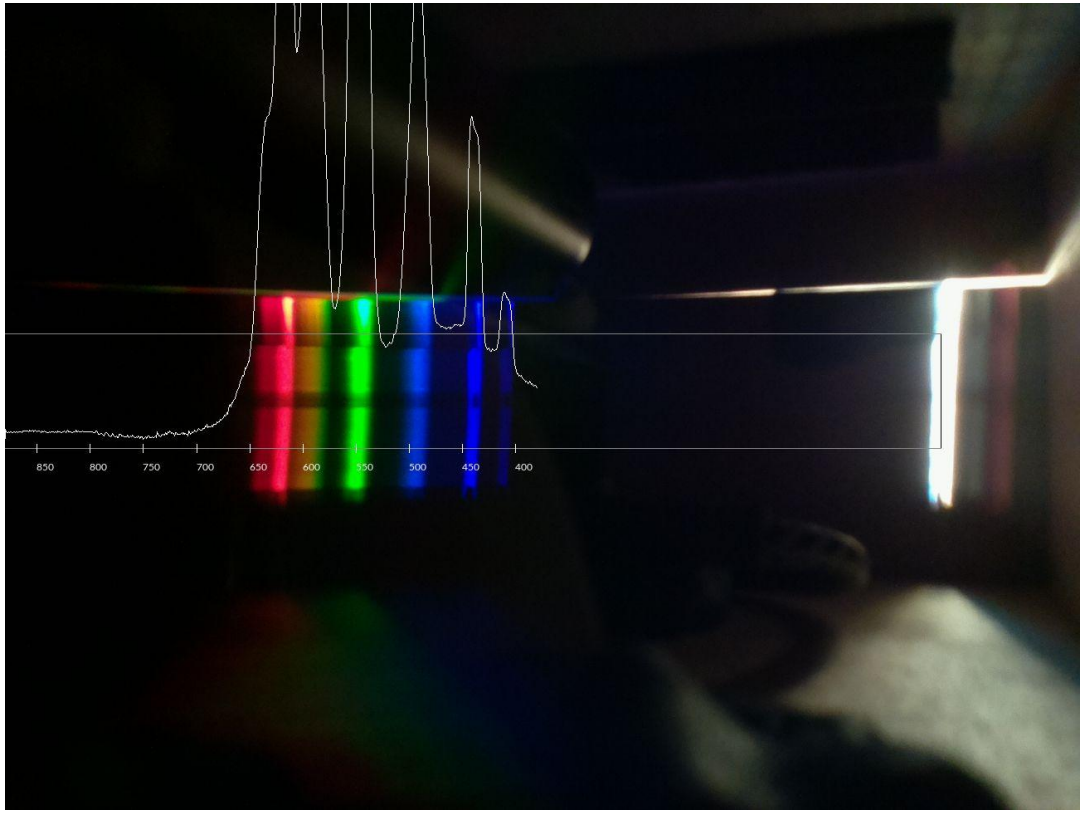


SPECTRAL COLOR CHART FOR NEON

PEAK WAVELENGTHS FOR NEON IN NANO_METERS ARE: 573 584 603 619 63

STRONG LINE WAVELENGTHS FOR NEON ARE: 585 607 615 626 640 837 86

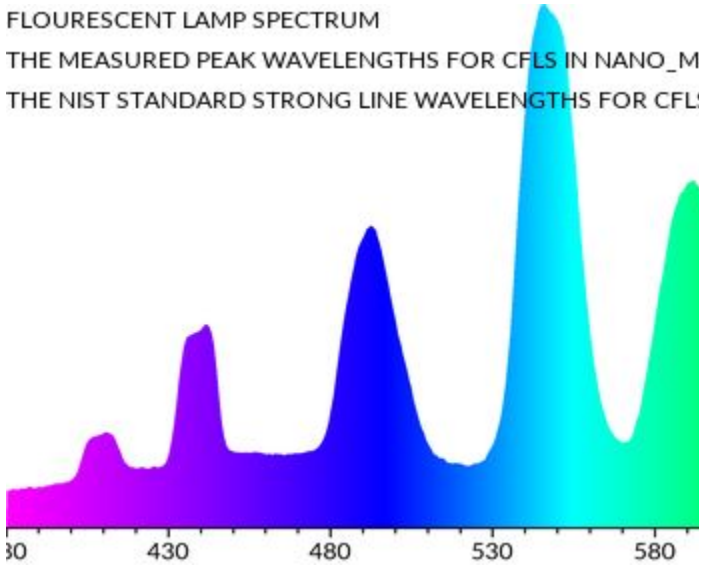


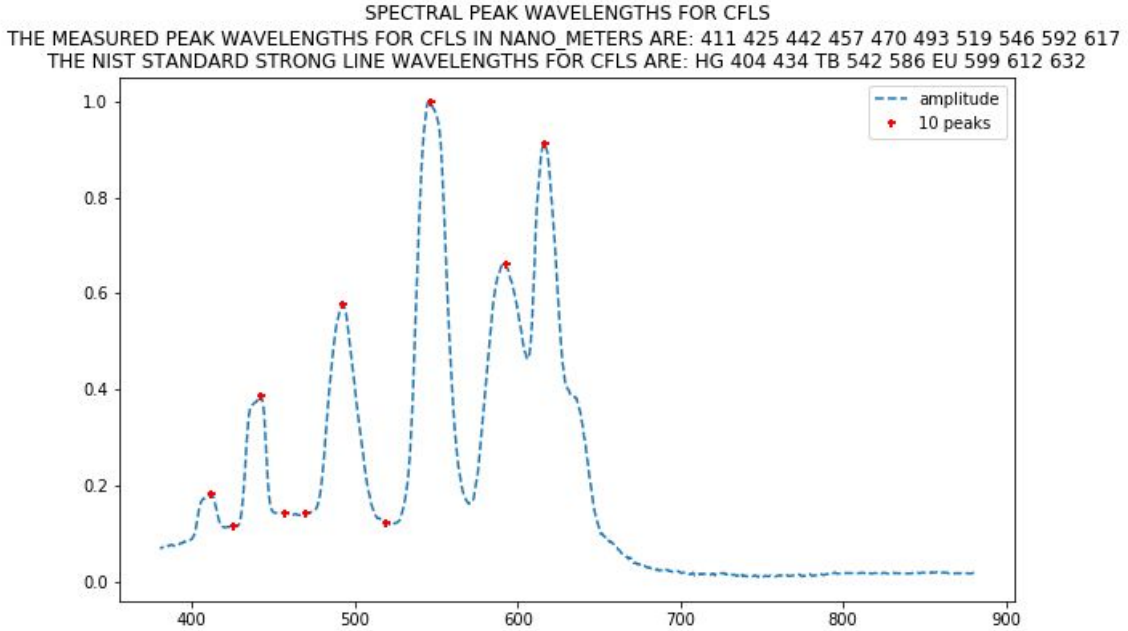


Student images of spectra - Fluorescent Lamp -

Contains Mercury, Terbium & Europium!!

Student images of spectra - Fluorescent Lamp - Contains Mercury, Terbium & Europium!!





Do you want to try getting a live image from the fluorescent lamp?

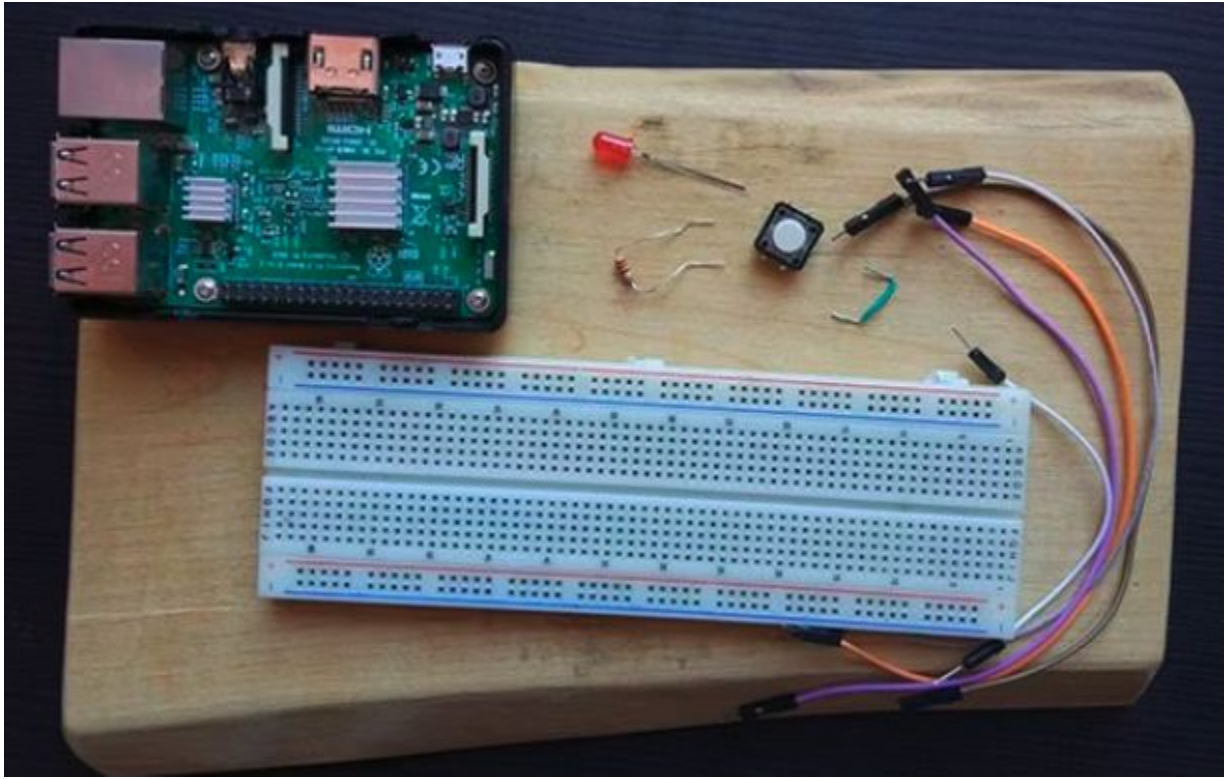
Ask a student to help you!

Tuesday
Day 6

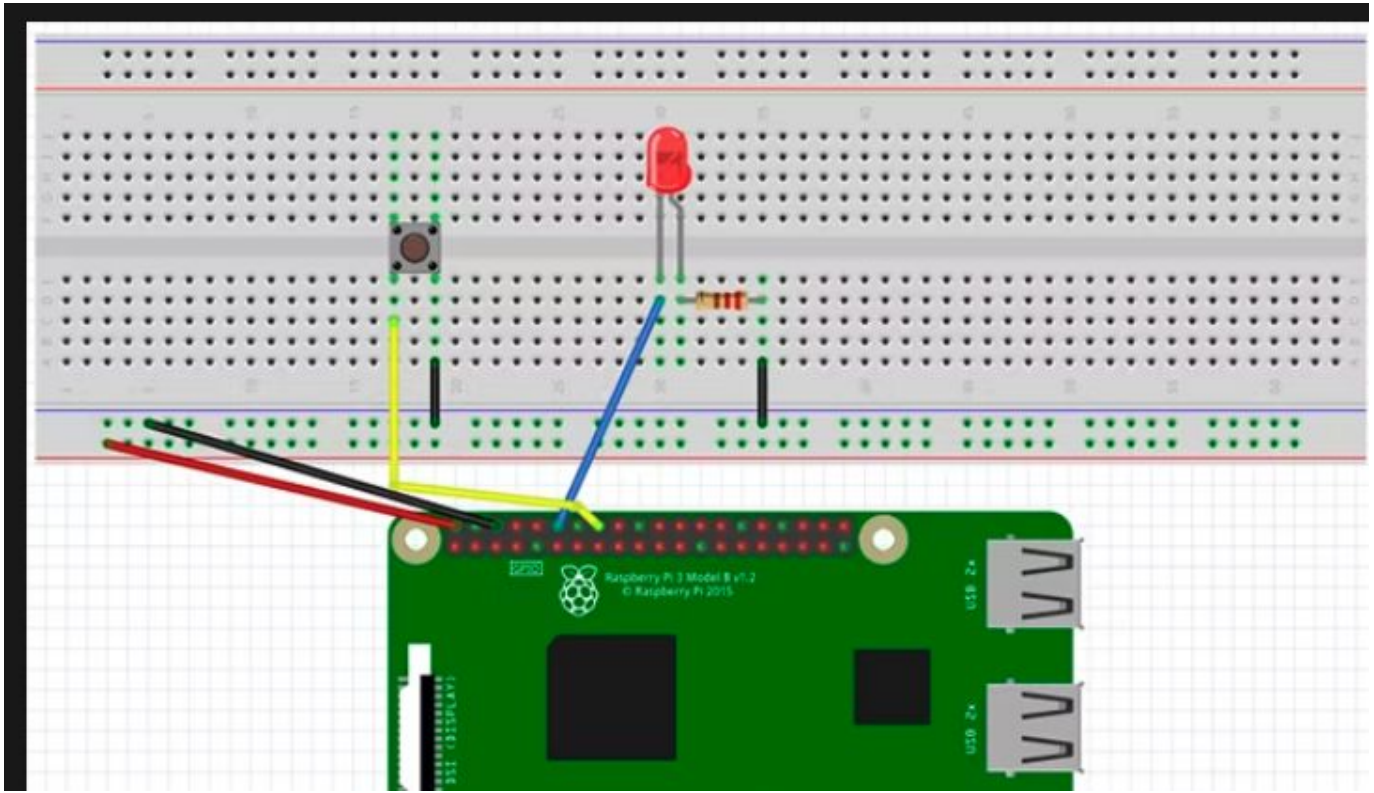
Raspberry PI GPIO - Breadboard circuits. I/O

- Connect & Wire a Breadboard to Raspberry PI General Purpose I/O Pins (GPIO)
- Learn to use Buttons, Motion Sensors, LED’s and Python code to control them
- Stop-Motion Animation
- Time-lapse Photography - create GIF file

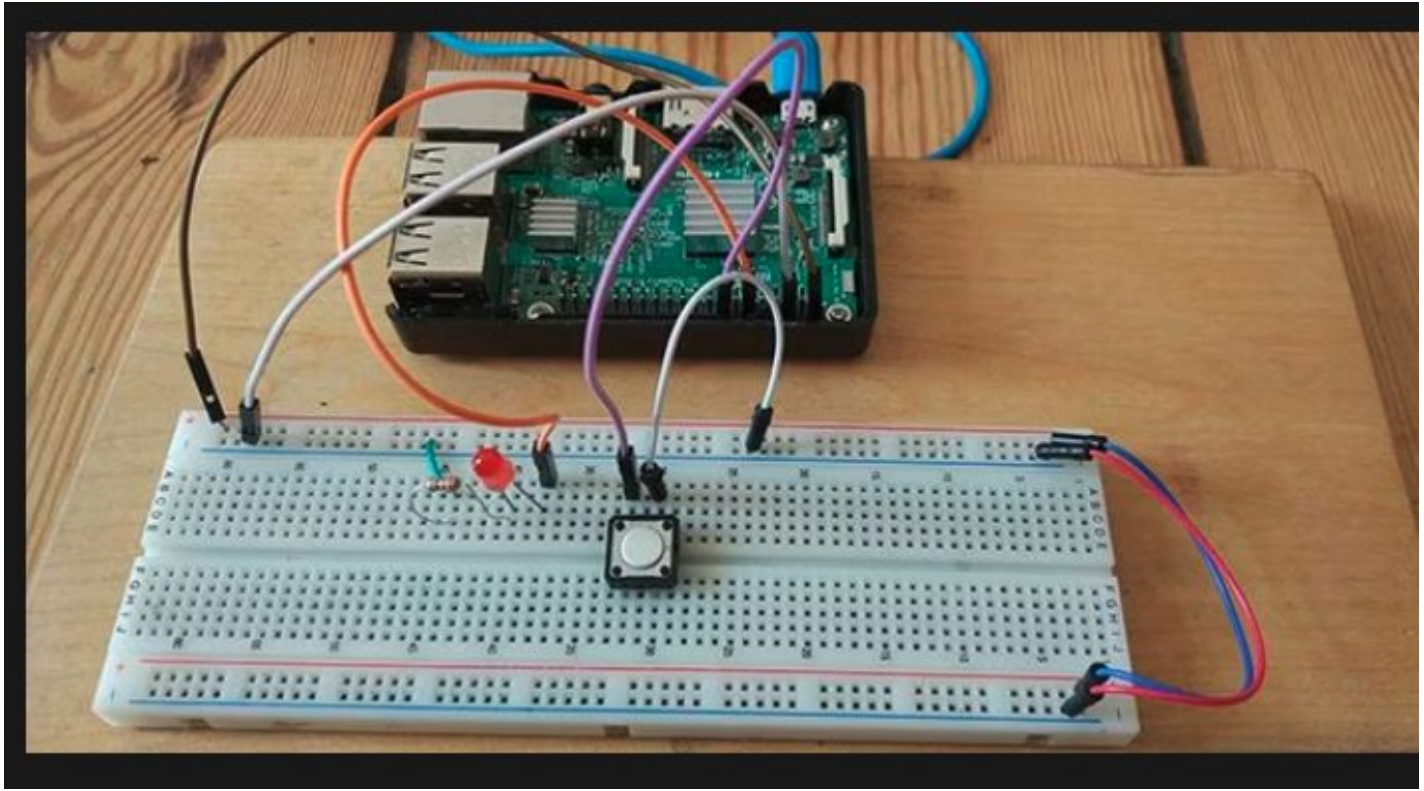
Connect LEDs and Button to rPI and Breadboard



Connect LEDs to rPI and Breadboard and make it blink!



Connect Button to rPI and Breadboard for Stop Motion and make it take a picture!



Wednesday
Day 7

Prepare final presentations & demos for Citizen Science Expo in the Park

- Process Time-lapse Images of Sprouts!
- Finalize experiments
- Finalize talking points
- Post Astro & other Images on Chart Boards
- Get snacks to distribute for citizen science day tomorrow!

Time Lapse video from RyPI55

Time Lapse video from RyPI56

Thursday
Day 8

Citizen Science Expo!

- Students invite assembled parents and teachers to the Citizen Science Expo
- Ask for help setting up in the Park
- Show of your results!!
- Students WILL ASK QUESTIONS OF PARENTS - THEY HOPE YOU PREPARED!
- Enjoy the final day of the workshop