

# COMPARATIVE STUDY OF TWO SOLAR ECLIPSES IN THE 21<sup>st</sup> CENTURY



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# 1. INTRODUCTION

Solar eclipses have been seen as incredible events since thousands of years ago. Anyway, they have also been considered terrifying because our ancestors couldn't understand why the sun disappeared for some hours.

For that reason, it was understandable to consider that their gods were sending them a message, a prophecy or a punishment.

Although we currently know why these events happen, we still consider those strange and scarce eclipses with fascination: it is difficult to believe that something so far away can influence our planet.

# 2. OBJECTIVES

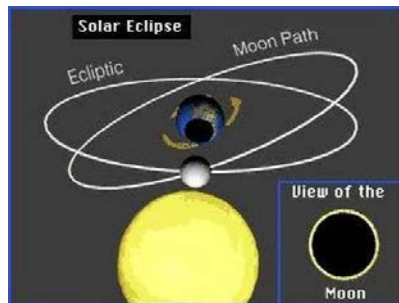
This work pretends to answer those questions based in two eclipses seen in Lleida, at Institut Guindàvols. One of them occurred on October 3<sup>rd</sup>, 2005 and the other one on March 20<sup>th</sup>, 2015.

1. To describe the creation process of a solar eclipse.
2. To get to know all the ways at our disposal to watch safely an eclipse.
3. To study some meteorological changes that happen during an eclipse
4. To compare the solar eclipse from 2005 and the 2015 one.

# 3. PREVIOUS KNOWLEDGES

## 3.1. MAIN CONCEPTS

**Eclipse.** This event happens when the Moon, the Sun and the Earth are aligned in the same nodal plane<sup>[1]</sup>. (Picture 1)



**Picture 1:** positions of the Sun, the Moon and the Earth during a sun eclipse. They are aligned for the modal plans.

Source: [http://i.ytimg.com/vi/xwGs8\\_otT64/hqdefault.jpg](http://i.ytimg.com/vi/xwGs8_otT64/hqdefault.jpg)

There are different types of eclipses (picture 2):

→ **Total eclipse** The moon is in a distance enough to hide completely the light of the sun on a part of the Earth, heating an almost completely darkness. In other parts of the Earth, it is a partial eclipse.



**Picture 2:** position of the Sun, the Moon and the Earth during a total eclipse and an annular one, respectively.

Source: <https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcTY0CqKINxBfw4Z0Wnn4JoyVidal-pe9X4h2ANAJKIsupkBr-gqTQ>

- **Annular eclipse.** The moon is too far from the Earth, and it is for that reason, that it doesn't completely hide the sun. For that reason, you can see a ring all around it.
- **Partial eclipse.** The moon doesn't hide completely the sun. This is the reason why, depending on where are you on the Earth, you can see one part or the other one of the sun. You can see this type of eclipse on those parts that aren't near the total or ring zone.



**Picture 3:** Photograph of the sun in the partial eclipse of 20/03/2015, courtesy of Josep X. Franch Peñas.

### 3.2. ADDITIONAL INFORMATION

#### - ECLIPSE 03/10/05



This eclipse stood up especially as it could be seen in its best magnitude from the central part of the Iberian Peninsula.

Although the eclipse could not be seen in its annular form from Institut Guindàvols, it was almost the same.

**Picture 4:** Places from where, the ring eclipse was seen (red line) places where it could have been seen as a partial eclipse (grey area)

Source:

<http://astroaula.net/wp-content/uploads/2013/05/f251.png>

## - ECLIPSE 20/03/15

This eclipse was a partial one from Spain. Anyway, it is worth to mention because the next important eclipse will take place in 2026. Another curiosity is that it happened the same day as the Spring equinox.



Picture 5: places where it could be seen as a total eclipse (orange area)

From:

[http://www.osae.info/saros/2015/2015\\_Stereographic\\_Magnitude\\_michael\\_zeiler.jpg](http://www.osae.info/saros/2015/2015_Stereographic_Magnitude_michael_zeiler.jpg)

## 4. HOW TO WATCH AN ECLIPSE

There are lots of ways to watch a Sun eclipse without any danger. But there are also lots of ways to do it incorrectly. For that reason, it is important to be informed of all the correct ways to watch it:

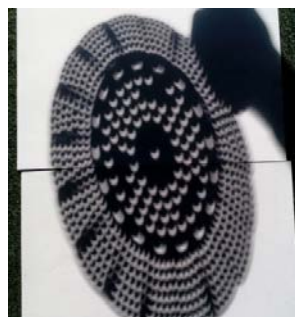
→ Through the little holes between the leaves of a tree.



**Picture 6:** projection of the sun on the floor through the little holes between the leaves of a tree. It has the same effect as a darkroom.

Institut Guindàvols 03/10/2005

→ Through the holes of a strainer.



**Picture 7:** an eclipse seen with the projection of the sun through the holes of a strainer.

From:

[https://enpolombia.files.wordpress.com/2015/03/img\\_20150320\\_105104.jpg?w=512](https://enpolombia.files.wordpress.com/2015/03/img_20150320_105104.jpg?w=512)



→ Through specialized glasses of black polymer.



**Picture 8:** Glasses used for watching the partial eclipse of 20/03/2015 by the pupils of Institut Guindàvols.

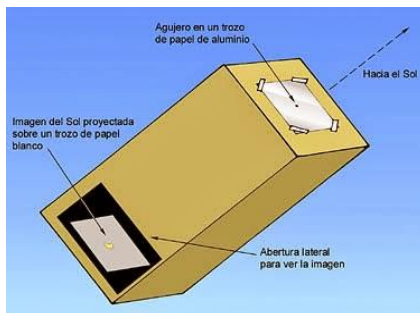
→ Through the thermoplastic glass of a solder mask.



**Picture 9 and 10 :** Pupils of Institut Guindàvols watching the eclipse through solder masks given by the solder workshop of Institut Guindàvols.

→ With a dark room

The drawback of the dark room is that the image of the eclipse is reversed, so in reality the image of solar eclipse looks backwards.



**Pictures 11 and 12:** representation of a dark room. The light passes through a small hole in one end, and is projected onto a screen of translucent paper in the other end.

<http://ciencia.diariodeavisos.com/2013/10/30/como-observar-el-eclipse-de-sol-de-este-domingo/>

Under any circumstances you should look directly to the sun without protection or through insufficiently protective objects. In that case, the damage to your eyesight will be very severe, even the constant observation of sunlight can cause even blindness.

## 5. METEOROLOGICAL CHANGES DURING AN ECLIPSE

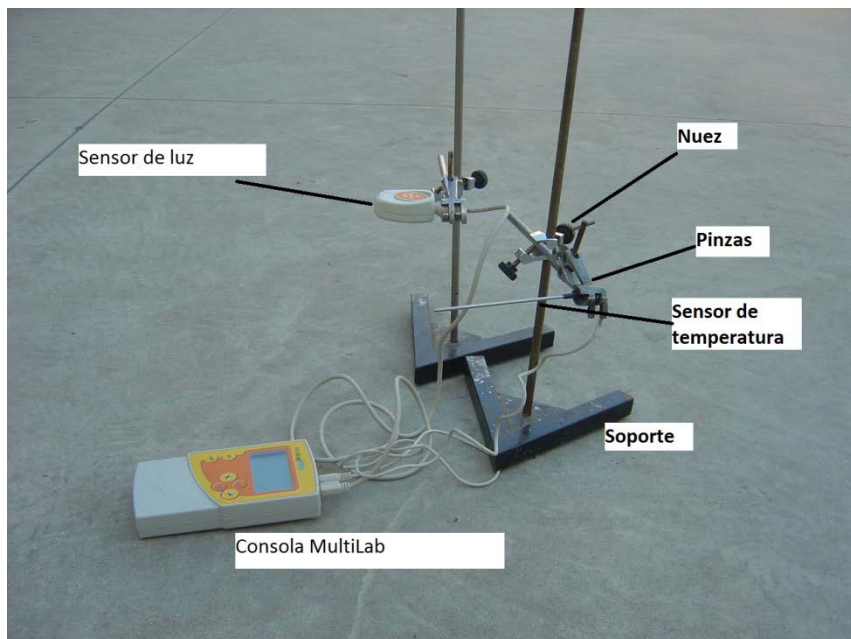
Although it is obvious that during an eclipse, weather is changing, we stopped to think about it. For this reason we decided to study these changes and as we had the opportunity, we compared it with the 2005 annular eclipse.

### 5.1. EXPERIMENTAL DESIGN

#### 5.1.1. DESCRIPTION

To check the relevant atmospheric changes, we decided to design an experiment for the day of the eclipse. In addition, we could compare data for the last eclipse.

Our experiment consisted of placing four sensors (light, temperature, humidity and pressure) in a place where they could appreciate the eclipse. These were connected to a console "MultiLogPRO" <sup>[2]</sup>, which works as a data acquisition system which is stored in its memory. After that we connected the console to a laptop to download the data. This is achieved with the "MultiLab" <sup>[3]</sup> program.



**Picture 13:** final version of the preparation and placement of sensors at the roof of the Institut Guindàvols, where we got most of the facts quote in this essay.

We didn't have any wind sensor and the results of the light intensity were not satisfactory. So, we had to ask for such data to the Meteorological Station of Lleida, located on the campus of Agrònoms <sup>[4]</sup>.

#### 5.1.2. MATERIAL

- Laptop.
- Program "MultiLab" and console "MultiLogPRO".
- Sensors of pressure, light, humidity and temperature.
- Special glasses to see the eclipse.
- Stands with nuts and clamps to hold the sensors.

### 5.1.3. PROCEDURE

1. Secure the sensors that are needed endured by a nut, and this in turn by tweezers caught by a support, as shown in image 13.
2. Connect the four sensors to the console.
3. Start the MultiLab program and select the method of capture, in this case, 1 sample every 10 seconds. Begin storing data at the beginning of the eclipse and stop when it is completed.
4. Download and save the data to the computer through "Multi Lab" to lock-jar with them later.

## 6. RESULTS

### 6.1. DAY 03/20/2015, PARTIAL ECLIPSE, Lleida.

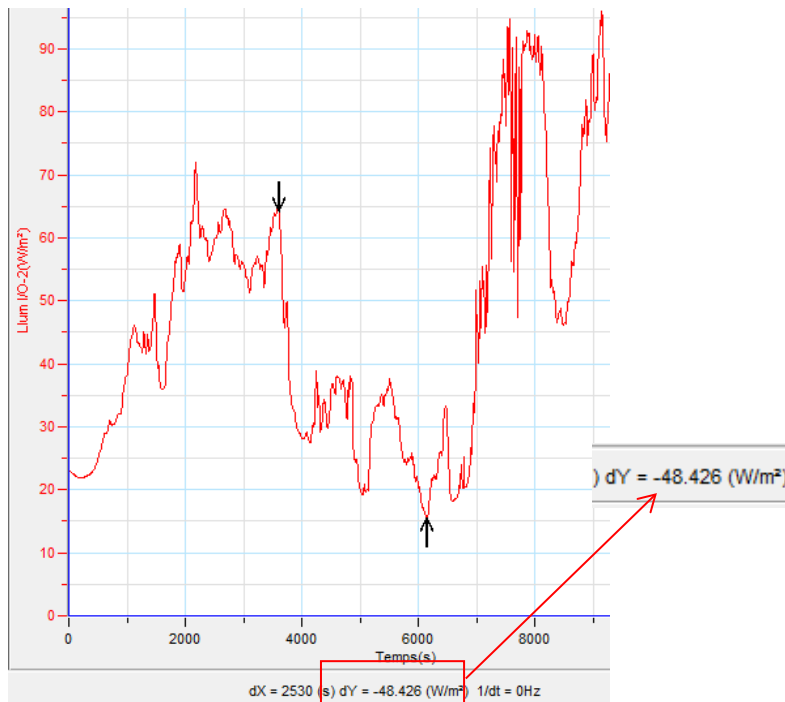
#### INTENSITY OF LIGHT

The image 14 shows how the insolation increases, at first it decrease and then it increase again. It must be clarified that peaks that we observed in the graphics because the eclipse day, was a cloudy day. The difference between the two marked points is 48.42, Klx equivalent to a 74.49%

$$65 \text{ Klx} - 100 \%$$

$$48,42 \text{ Klx} - X \%$$

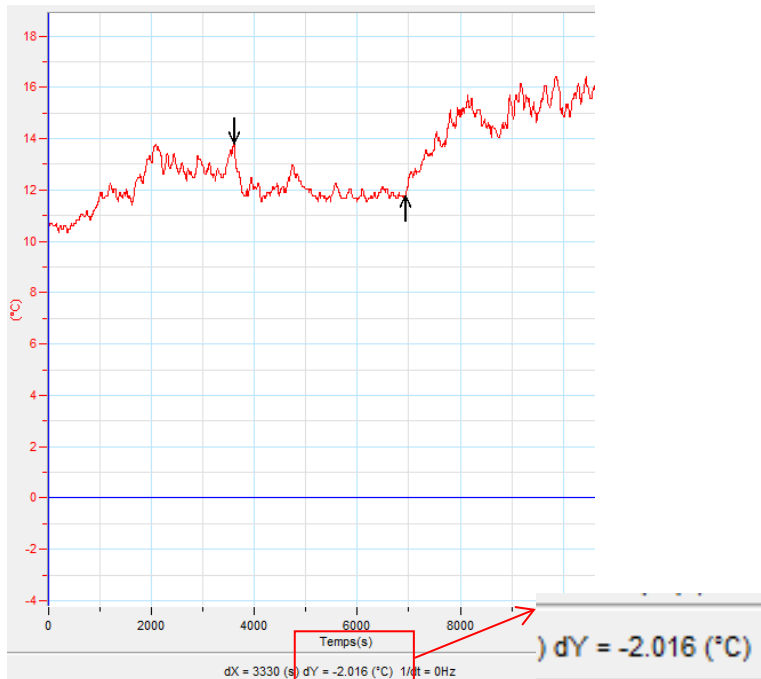
$$\frac{48,42 \cdot 100}{65} = X \rightarrow 74,49 \%$$



**Picture 14:** graph of the insolation (KLX) with the difference between the highest and the lowest specified and expanded.



## TEMPERATURE



**Picture 15:** graph of temperature (C °) with the difference between the highest and the lowest specified and expanded.

The graph of the temperature is more stable, because their data were unaffected at cloudy day. Anyway, we can see that with the passing of time the temperature increase, and just as the eclipse began, it slowly decrease until a difference of 2,016 C° (Picture 15). After the eclipse, the temperature continued to rise as you would any day.

$$14 \text{ C}^{\circ} - 100 \%$$

$$2,016 \text{ C}^{\circ} - X \%$$

$$\frac{2,016 \cdot 100}{14} = X \rightarrow 14,4 \%$$

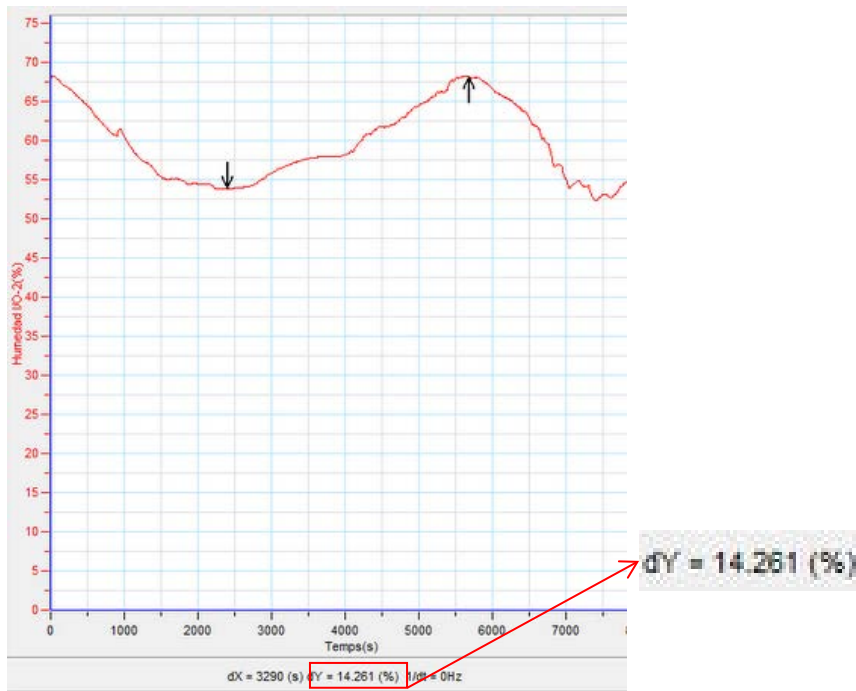
## RELATIVE AIR HUMIDITY

On picture 16 we can clearly see the low humidity and at the end of the eclipse, it rises up regularly, until a difference of 20.97% between both extreme points.

$$68 \% - 100 \%$$

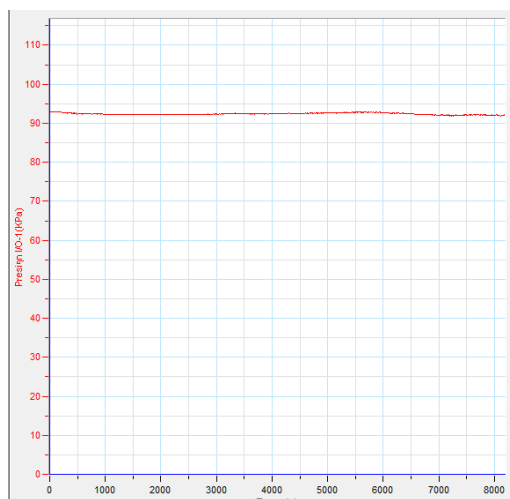
$$14,261 \% - X \%$$

$$\frac{14,261 \cdot 100}{68} = X \rightarrow 20,97 \%$$



**Picture 16:** graph of the relative air humidity during the eclipse with the difference between the highest and the lowest specified and expanded.

## PRESSURE



**Picture 17:** graph of pressure (kPa)

The pressure didn't change during the eclipse, so we can conclude that it does not affect in the eclipse.

## WIND STRENGTH (WS) AND WIND DIRECTION (WD)

The facts due to wind's speed and direction were provided by the Meteorological Station of Lleida and they are shown in the next chart.

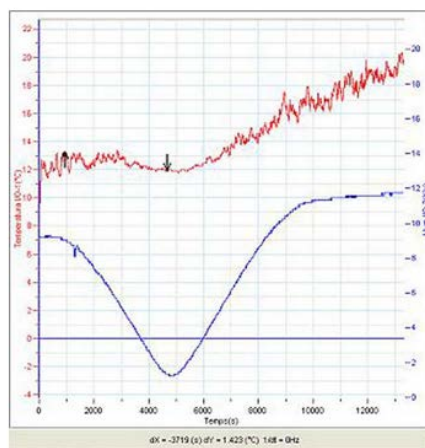
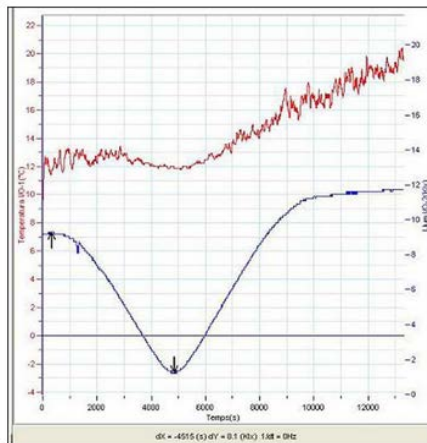
It is noticed that in the central hour of the eclipse there was an important drop in wind's speed. Relating to wind's direction, it is hard to appreciate any change as it is used to being uneven.

Hour	WS (m/s)	WD (°)
7	0,4	189
8	1,8	267
9	1,2	285
10	0,9	195
11	2,1	210
12	2,2	203
13	1,9	190
14	2,2	198
15	2	229

## 6.2. DAY 03/10/2005, ANNULAR ECLIPSE

All the shown facts were taken by a group of students <sup>[5]</sup> of our high school who participated in the contest "Catch a Star 2005" ten years ago.

### INTENSITY OF LIGHT AND TEMPERATURE



**Images 18 y 19:** graph of the temperature (red line) and intensity of light (blue line)

Highest intensity of light	9,315 Klx
Highest intensity of light	1,215 Klx
Light variation	8,1 Klx → 87%

$$9,315 \text{ Klx} - 100 \%$$

$$8,1 \text{ Klx} - X \%$$

$$\frac{8,1 \cdot 100}{9,315} = X \rightarrow 87\%$$

Highest temperature	13,32 °C
Lowest temperature	11,799 °C
Temperature variation	1,128 °C → 8,47 %

$$13,32 \text{ } ^\circ\text{C} - 100 \%$$

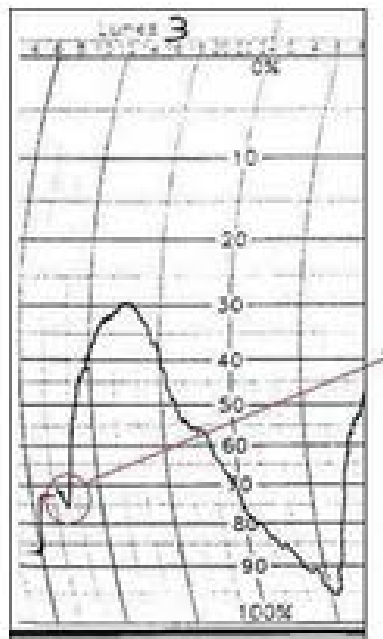
$$1,128 \text{ } ^\circ\text{C} - X \%$$

$$\frac{1,128 \cdot 100}{13,32} = X \rightarrow 8,47\%$$

It is noticed that the lowest points in both temperature and intensity of light coincide in time. **Intensity of light decrease 87%**, while **temperature fell 1,1 °C**.

## RELATIVE AIR HUMIDITY

As temperature suffers a noteworthy fall, it is understandable that humidity could experiment an increase since these two factors are used to being closely linked.

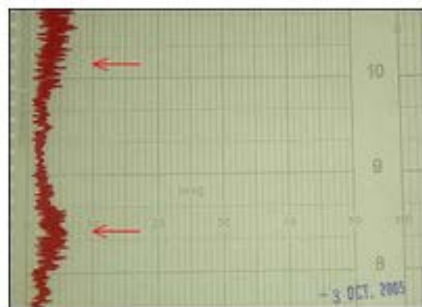


**Image 20:** graph of the relative air humidity, provided by the Meteorological Station of Lleida.

Indeed, a rise in the relative air humidity is noticed during the eclipse, going up from 70% to 75%.

## WIND STRENGTH

Air masses tend to move quicker once they are submitted to high temperatures. If the temperature decreased during the eclipse, it's foreseeable wind speed would suffer a decrease as well, as it is shown in image 21.



**Image 21:** graph of the wind direction and strength, provided by Meteorological station in Lleida.

It is noted that between eight and ten in the morning (period when the eclipse was shown), **a drop of the wind strength is produced**.

## 7. CONCLUSIONS

1. An eclipse is formed when the Moon's, Sun's and Earth's node planes are lined up so that Moon is placed between the planet and the star. From this point on, several sorts of eclipses might be formed: partial eclipse, total eclipse or annular eclipse.
2. There is a great number of ways to observe an eclipse safely: by projecting solar light through trees' leaves holes; by projecting solar light through a cooking strainer's holes; by using special eclipse viewing glasses; through a thermoplastic soldering mask or through a camera obscura.
3. During the annular eclipse (3/10/2005), intensity of light diminish an 87% (8.1 Klx), temperature decreased an 8.47% (1.128 °C), relative air humidity suddenly raised (from 70% to 75%) and wind speed slowed down because of temperature and humidity fall. During the partial eclipse (20/03/2015), intensity of light diminish a 74.49% (48.42 Klx), temperature fell till 14.4% (1.016 °C), relative air humidity raised a 20.97% and wind speed slowed down, although pressure didn't change at all (which means it is not affected by the eclipse)
4. It is noticed in both eclipses temperature, intensity of light and wind speed diminished, while relative air humidity raised. In 2005 eclipse, intensity of light fell deeper than in 2015 one as the concealment percentage was higher. Nevertheless, eclipse partial's temperature diminished more than in 2005.

## 8. ACKNOWLEDGEMENTS

Thanks to the Meteorological Station of Lleida, to Susana Martín and Armand Álvarez for attending to Institut Guindàvols students and for providing us every piece of help we needed.

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Thanks to Rosa Borrell, who helped us correcting the English version of this essay and did her task amazingly fast and with a lot of sense of humour.

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2. MultiLog Pro: <http://fourieredu.com/store/products/multilogpro/#.VVUBzPntmko>
3. MultiLab: <http://fourieredu.com/store/products/mutilab4/#.VVYZY0YgHYg>
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