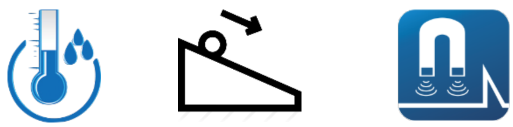
NeuLog

Panda

Explore Science

Temperature Light Sound Barometer Altitude Humidity



Dew-point Acceleration Magnetic field

Panda
Explore Science

4_6

Contents

Exploring Science

The laws of nature are at the base of every technological system. From the way machines operate to modern agriculture, distillation and even electric and electronic systems, there is always a natural process assisting the technology.

In this book, we take a deep dive into different phenomena: light, sound, air-pressure, humidity and more. We turn theory into substance by first exploring the senses, then by making a comparison to measurements taken by electronic sensors.

By using the PANDA 9 in 1 portable lab, children receive real-time measurements and feedback to what they do as they do it. Phenomena that are difficult to grasp are illustrated and materialized before their eyes.

The "PANDA – First Steps in Science" book is a step-by-step instructor's guide that leads young children into the world of science, by exploring their environment.

The "PANDA – Explore Science" book includes advanced experiments for self-practice, guided by an instructor.

Each book offers an easy trail to follow, guiding a young child through this fascinating world of science, creating a strong base for the future, for every path he/she chooses later on in life.

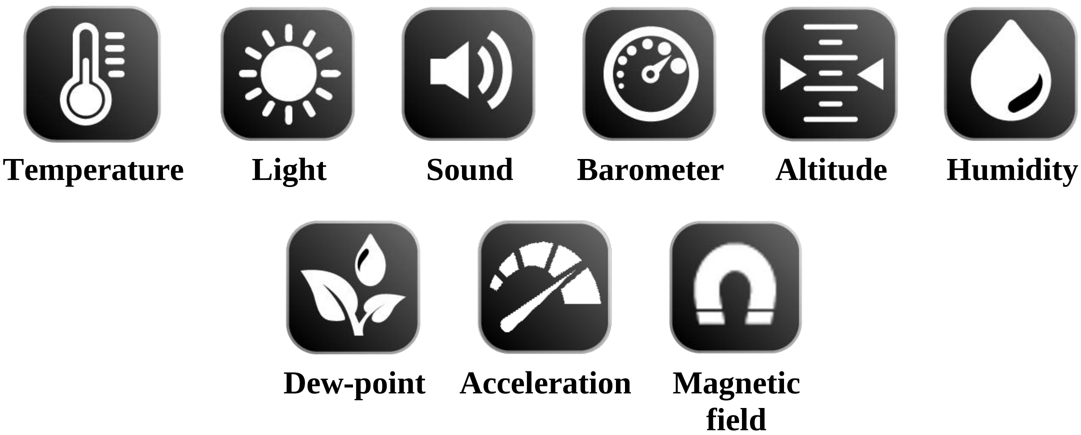
PANDA – 9 in 1 Portable Lab

The PANDA is a colorful display, touchscreen, sensor lab that brings science to life by making it tangible. It is the primary school tool for excellence in environmental data collection and for experiments in biology, physics and chemistry.

The PANDA's real-time display of measurements, feedback and graphs strongly connects a child's sensations or actions in nature to the phenomena, making it easier to explain complex laws of nature.

Features:

The PANDA is a multi-sensor module that includes 9 built in sensors:



The PANDA also includes:

- A 3.2" (320 x 240 pixels) color display
- A touchscreen
- A USB connector
- A rechargeable battery

Data analyzing modes and display options:

The PANDA has two modes for performing sensor measurements: ***Normal*** and ***Experiment***.

Normal mode:

In this mode, the panda displays real-time measurements of a chosen sensor.

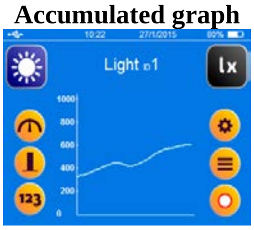
The normal mode has 4 display options:

Digital

Bar

Analog meter

Accumulated graph



Experiment mode:

In this mode, the PANDA records the measurements of ***all*** sensors participating in an experiment over a pre-determined period of time.

The PANDA can display an experiment's results, 2 sensors at a time.

The Panda software, for PC, MAC or tablet:

The data collected by the PANDA can be further analyzed with the PANDA software, specially designed for primary schools, using a PC, a MAC or a tablet. It is super friendly and intuitive to use.

Lesson structure

The experiments in this book are self-practice for students at ages 9-14. It is recommended that the teacher introduces the experiment and summarizes it.

While students perform the experiments, the teacher can guide them and discuss the experiment with them in small groups.

It is recommended to let the students work in small groups with a single experiment's worksheets at a time.

Each experiment has its own worksheets, where the students write down the experiment's results and reports.

You can download the worksheets as an open WORD document from the **www.neulog.com** site and hand them out.

You can edit the experiments and adapt them to your students and to the way you teach.

After all groups of students finish the experiment, a class discussion to summarize the subject can commence.

Make the introduction short and expand the discussion and summary (do not overdo it, of course).

Discussing the subject before the experiment increases and sharpens the gap between the students, bores them and makes it difficult for them to see where it leads them. On the other hand, everything is clearer in the summary and everyone can participate in the discussion.

Students will develop talking and listening skills during discussions, as well as research and cooperation skills.

Experiment reports

The report is the most important part of the experiment. It shows what the students have learned, and it helps them to understand and remember the experiment and to analyze their results.

Every experiment report should have:

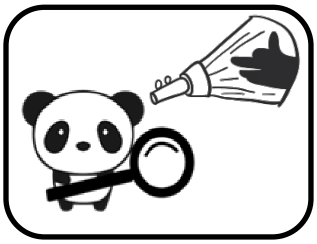
1. The experiment title.

2. A short description of the experiment objectives and what is measured and tested.

3. The experiment results in tables, graphs, or Panda screens.

4. Summary and conclusions.

Experiment 2.1 – Light and Shadow



Objectives:

- To learn about the concepts of light and shadow.
- To investigate how light intensity and temperature change between a sunny area and a shaded one.

Modules and Sensors:

- PANDA multi-sensor

Introduction:

Light is a form of energy made of photons. The sun is our biggest source of light. We also have electric light bulbs and candles that bring us light. A shadow is made when an object blocks the light. The object must be opaque or translucent to make a shadow. A transparent object will not create a shadow, as light will pass straight through it.

In this experiment, you will investigate how light intensity and temperature change between a sunny and a shaded location.

Procedure:

Experiment setup

1. ***Choose*** a location that is exposed to the sun, and a shaded location (below a tree for instance).

> **Do not use the Panda outside when it is raining. It is important to not get the Panda wet!**

Settings

2. ***Press*** on the button on the upper left side of the screen.

3. ***Use*** the ***arrows***   to select the ***Light sensor***.

4. ***Press*** on the ***lx*** button on the upper right side of the screen.

5. ***Press*** on the ***0-60,000 lx*** button (if you see that you need a higher range during the experiment, change it to ***0-240,000 lx***).

Testing and measurements

6. ***Go*** to the shaded location and ***point*** the sensor towards the sky (vertical to the ground).

7. ***Write down*** the value in the following table.

Light intensity in the shaded location (lx)	Light intensity in the sunny location (lx)

8. ***Go*** to the sunny location and ***point*** the sensor towards the sky (vertical to the ground).

9. ***Write down*** the measured value (in the left column) in the above table (step 7).

10. ***Press*** on the ***Light sensor***  button on the upper left side of the screen.

11. ***Use*** the ***arrows***   to select the ***Temperature sensor***.

12. If the **°F** button is seen on the upper right side of the screen, ***press*** it and ***choose*** **°C**.

13. ***Go*** to the shaded location and ***measure*** the temperature.

14. ***Write down*** the measured value (in the right column) in the following table.

Temperature in the shaded location (°C)	Temperature in the sunny location (°C)

15. ***Go*** to the sunny location and ***measure*** the temperature. The values might continuously go up because the internal temperature sensor is getting warmed up by the sun.

16. ***Wait*** about 2 minutes and ***write down*** the measured value (in the left column) in the above table (step 14).

17. ***Change*** the measuring units to ***°F***.

18. ***Measure*** again the temperatures in the sunny and shaded areas and ***write down*** the measured values in the following table.

Temperature in the shaded location (°F)	Temperature in the sunny location (°F)

Summary questions:

1. Explain your light intensity results. Why were the values different between the shaded and the sunny locations?

2. Explain your temperature results. Why were the values different between the shaded and the sunny locations?

3. Did you perform the experiment in a sunny or cloudy day?

4. How would that affect the results?

Measuring light using the PANDA:

A light sensor measures (in lux units) the light that flows around it (light intensity per unit area).

When the sensor is not aimed towards a light source, the measured light intensity is the general light indoors reflected from the walls and various objects in the room.

Experiment 2.2 – Loud and Soft Sounds

Objectives:

- To distinguish between loud and soft sounds.
- To study the sound levels of different sound sources (musical instruments, your voice, different recorded sounds).

Modules and Sensors:

- PANDA multi-sensor

Materials:

- Musical instruments
- A smart phone app with different types of sounds

Introduction:

Sound is a type of energy made by vibrations. Sound is produced when an object vibrates. For instance, when a drum is struck, it vibrates. The vibrations cause movement in the air particles which bump into the particles close to them. These particles vibrate, causing them to bump into more air particles. This movement is called sound waves. It keeps going until the particles run out of energy.

If your ear is within range of the vibrations, you can hear the sound. Sound intensity is the amount of energy a sound has over an area. In general, sounds with a higher intensity are louder.

The ear has a membrane called ear drum. The sound vibrations vibrate the ear drum and these vibrations are translated into sounds.

Procedure:

Experiment setup

1. ***Make sure*** you have some musical instruments and different types of recorded sounds.

Settings

2. When ***opening*** the Panda, the **Sound sensor**  button should appear on the upper left side of the device. If you see a different button, ***press*** on it and ***choose*** **Sound**.

Testing and measurements

3. ***Change*** the Panda mode to ***Column mode***  or ***Gauge mode*** .

4. ***Be quiet*** and ***watch*** the Panda screen. Does the value change? ***Fill*** the following table with the value you see.

Type of sound	Sound level (in dB)

5. ***Point*** the Panda's side with the small icons toward your hands. ***Clap your hands*** and ***watch*** the screen. ***Fill*** the table at step 4 with the value you see.

6. ***Take*** a musical instrument and ***produce*** a low/soft sound. ***Fill*** the table at step 4 with the value you see.

7. ***Take*** a musical instrument and ***produce*** a high/loud sound. ***Fill*** the table at step 4 with the value you see.

8. ***Repeat*** this process with other recorded or not recorded sounds such as talking, whispering and shouting.

Summary questions:

1. Which type of sound had the lowest level (soft)?

2. Which type of sound had the highest level (loud)?

3. Did you measure sounds that were close to 40 dB?

4. Did you measure sounds that were close to 100 dB?

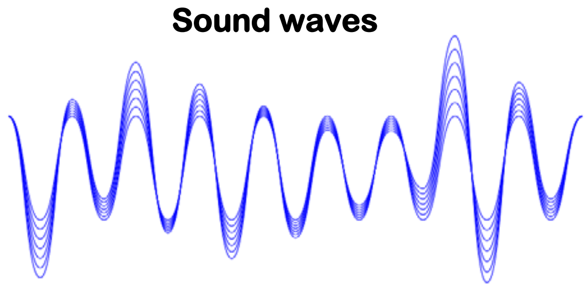
5. Are emergency sounds loud or soft? Explain why.

Summary and more to know

Ears and sound:

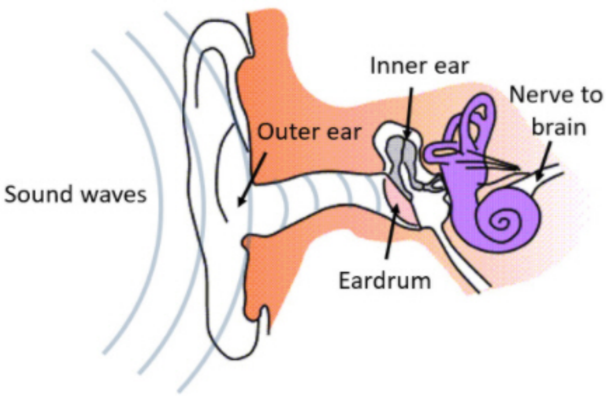
Sound comes from vibrations.

These vibrations create sound waves.



Sound waves move through air, water or even solid objects before reaching our ears.

These sound waves vibrate the ear drum in our ear.



Our brain translates the vibration back to sounds.

The human ear has an amazing ability of being able to hear and understand different sounds at the same time. We can hear and understand someone speaking to us, while listening to music on a busy street, full of noises.

Did you know?

Many animals use sound to detect danger and escape attacks.

Dogs can hear sound at a higher pitch than humans, which means that they can actually hear noises we can't!

Measuring sound using PANDA:

The unit for measuring sound levels is called decibel (dB).

The decibel is the common unit of sound measurement. A decibel is one tenth of a bel (B), or 10 decibels equal 1 bel.

Alexander Graham Bell:

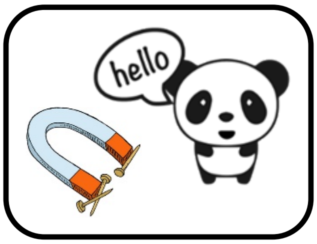
The bel unit was named after Alexander Graham Bell, an American inventor, scientist and engineer who invented the first practical telephone.

Here are some common examples of noises and their dB levels:

10 dB – Breathing
50 dB – Whisper, leaves rustles
70 dB – Street noise
80 dB – Vacuum cleaner
105 dB – Alarm clock
115 dB – Drilling machine
145 dB – Airplane taking off

Next time you hear a noise, try to figure out how many decibels that noise produces.

Experiment 2.3 – Magnetic Field



Objectives:

- To learn about the basic properties of magnets.
- To compare the magnetic field strength between two poles of a magnet, between different distances from the poles, and between different magnets.

Modules and Sensors:

- PANDA multi-sensor

Materials:

- 2 types of bar magnets Magnet 1 

  Magnet 2 
- Ruler

Introduction:

A bar magnet has two ends, known as magnetic poles. One pole is called the North pole of the magnet and the other pole is called the South pole of the magnet.

'Unlike magnet poles' attract each other and 'like magnet poles' repel each other.

Magnets also attract other materials which are not normally magnetic (various sorts of metals). The magnetic field is stronger near the poles of a magnet.

The term magnetic field refers to an area where there is a magnetic attraction.

Procedure:

Experiment setup

1. ***Make sure*** you have two types of bar magnets and a ruler.

Settings

2. ***Press*** on the button on the upper left side of the screen.

3. ***Use*** the ***arrows*** to select the ***Magnetic field (magnetic) sensor***.

4. ***Press*** on the ***Range*** button on the upper right side of the screen (will show **µT** or **360°**).

5. ***Press*** on the ***X axis*** button.

Testing and measurements

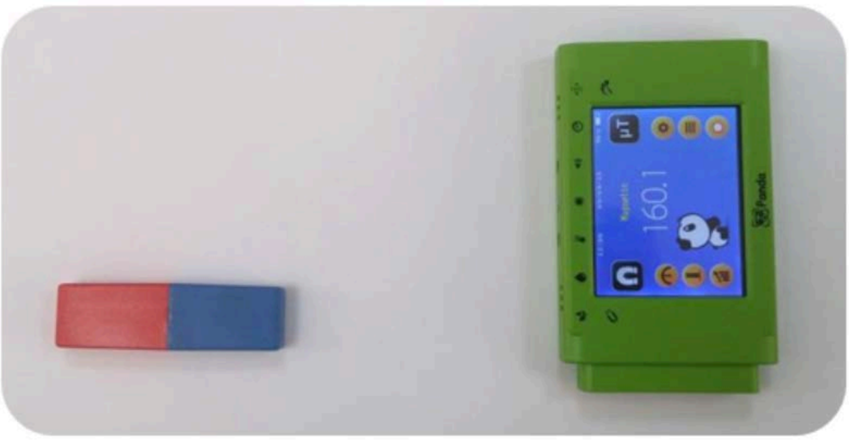
6. ***Place*** the Panda on the table and the magnets far away from the Panda.

7. In this arrangement, ***measure*** the magnetic field. The measured value is a result of the Earth's magnetic field.

   This value should be subtracted from the measured values received later on.

   Do not move the Panda during this experiment.

8. ***Place*** the blue side of magnet 1 opposite the Panda (at a distance of 5 cm).



9. ***Fill*** in the value you see on the Panda in the table below:

	Magnetic field (µT) – Blue side (South pole)	**Magnetic field (µT) – Red side (North pole)**
Magnet 1: 5 cm		
Magnet 1: 10 cm		
Magnet 1: 15 cm		
Magnet 2: 5 cm		
Magnet 2: 10 cm		
Magnet 2: 15 cm		

10. ***Repeat*** the measurement for 10 and 15 cm distances and ***write*** the results in the above table (step 9).

11. ***Turn*** the magnet so its red side will face the Panda (at a distance of 5 cm), and ***write*** the result in the above table (step 9).

12. ***Repeat*** the measurements for 10 and 15 cm distances and ***write*** the results in the above table (step 9).

13. ***Repeat*** steps 8-12 with magnet 2 and ***write*** the results in the above table (step 9).

14. ***Turn*** the magnet so it will be parallel to the Panda and at a distance of 5 cm.

15. What is the strength of the measured magnetic field?

16. ***Move*** the magnet to the side of the Panda.

17. What is the strength of the measured magnetic field?

18. ***Explain*** the difference in the measurements according to the magnetic field lines.

19. ***Hold*** the Panda horizontally in your hand and ***step away*** from the table with the magnets.

20. Slowly ***spin around*** and observe how the magnetic field strength changes while you spin.

21. ***Locate*** the place where the magnetic field strength is maximal and positive.

    Is it the North?

22. ***Tilt*** the Panda a little towards the floor and then towards the ceiling and ***note*** that the maximal and positive magnetic field strength changes.

    Is it the South?

23. ***Tilt*** the Panda a little towards the floor and then towards the ceiling and ***note*** that the maximal and negative magnetic field strength changes.

24. The Panda can be used as a compass.

    Change the measuring range from X to angle.

    The Panda will show its angle in relation to the North.

25. ***Hold*** the Panda horizontally and ***observe*** the readings changing from 0 to 359 and back to 0.

Summary questions:

1. Was the value higher or lower when the magnet was closer to the Panda? Explain these results.

2. What was the main difference in the values while measuring the two sides of the magnets?

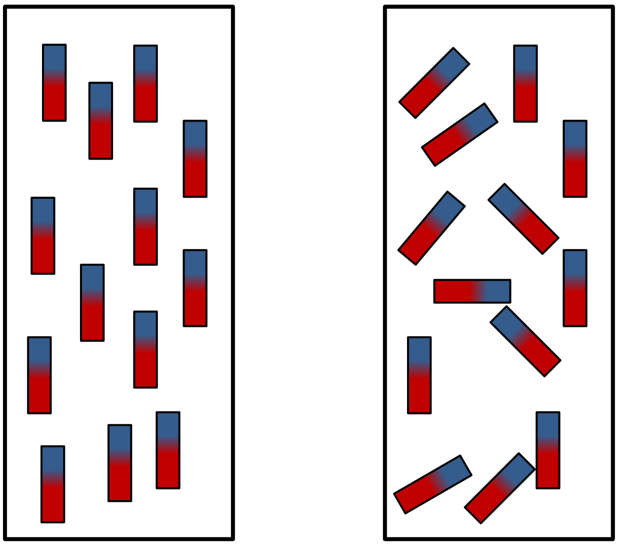
3. According to your results, which magnet is stronger – magnet 1 or magnet 2? How can you demonstrate it without using the Panda?

4. When measuring the Earth's magnetic field, why the magnetic field strength towards the North is different from the magnetic field strength towards the South?

Summary and more to know

Magnetic materials:

All matter in nature has many little magnets in it, but as we saw in the beginning of the lesson, not all matter behaves as magnets.



Magnet   Non-Magnet

In non-magnet matter, all the little magnets inside rest in different directions, cancelling each other out and thus cancelling the magnetic attraction.

In magnetic matter, a large number of these magnets inside are aligned in the same direction, thereby enabling the magnetic attraction.

Some matter can be turn into magnets. With these types of matter, the little magnets can be aligned in the same direction.

When we place a paper clip next to a magnet, for example, the little magnets in the paper clip turn to align in the direction of the magnet. The paper clip becomes a magnet in itself, attracting another paper clip in a similar fashion.

Magnets attract certain metals in nature, but not all. The main material we use to make magnets today is Iron.

Magnetism:

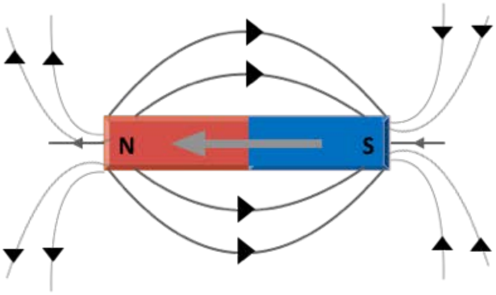
Magnetism is an invisible force or field caused by the unique properties of certain materials.

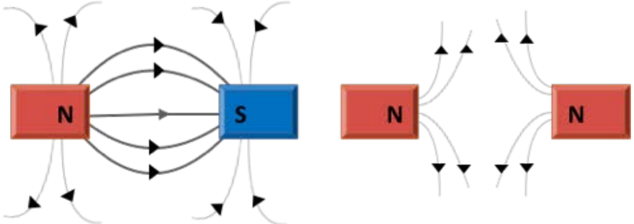
In a magnet there are two poles: a North-seeking pole and a South-seeking pole.

The magnetic force in a magnet that flows from the North pole to the South pole. This creates a magnetic field around a magnet.

A North and a South pole will attract each other.

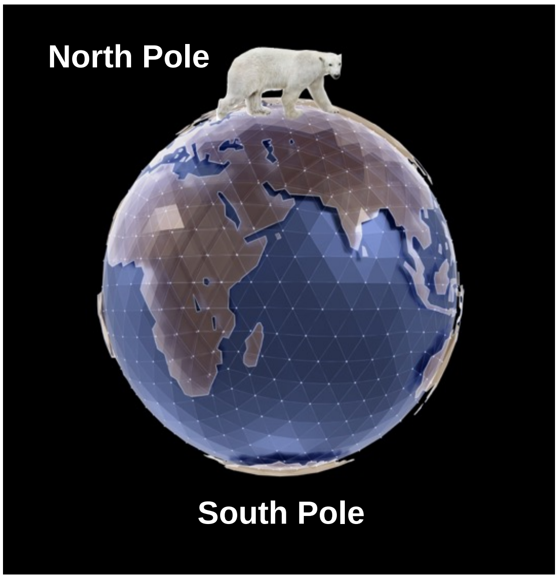
Two North poles or two South poles will repel each other.





The Earth behaves as a magnet.

The Earth poles are the North Pole and the South Pole.



Magnetic compass:

The magnetic compass is a light weight magnet that floats on liquid and rotates on an axis.

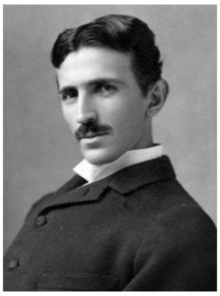
The magnetic compass's poles are aligned with the Earth's poles. The compass' North needle turns towards the Earth's North pole, thus pointing to the North.

Measuring magnetic fields using PANDA:

The unit for measuring the magnetic field strength is called Microtesla (µT).

Micro means one millionth (one divided by a million).

Nikola Tesla:



Nikola Tesla was a Serbian-American inventor, electrical engineer, mechanical engineer and physicist. Many consider Tesla one of the greatest inventors of all time.

Tesla invented the alternating current (AC), upon which all modern electricity networks are based. He invented both the induction motor and a generator that runs on alternating current.
He also invented radio broadcasting, although it was attributed to Marconi.

Unfortunately, and although his many inventions are used all over the world, Tesla died destitute.

Experiment 2.4 – Barometric Pressure and Altitude

Objectives:

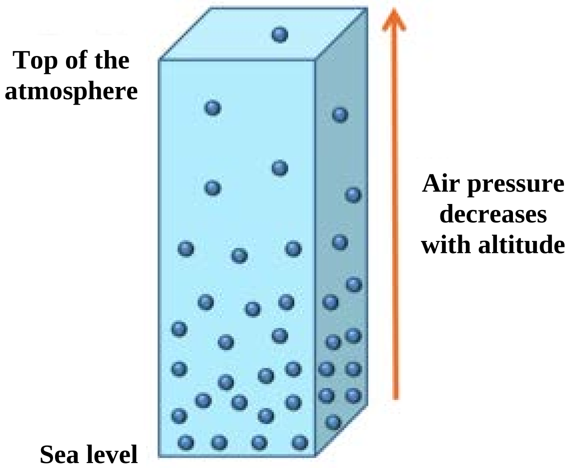
- To learn about the connection between barometric/air pressure and altitude.
- To explore barometric pressure and altitude measurements at different heights.

Modules and Sensors:

- PANDA multi-sensor

Introduction:

Barometric pressure (air) is the pressure within the atmosphere of Earth. When the number of air molecules above this area is high, more molecules activate force on this area, which means that the barometric pressure will be high. The size of the barometric pressure at sea level is approximately 1 atm. As the altitude increases, the pressure decreases. The barometric pressure fades exponentially. Every time you climb 5 Km above the surface of the Earth, the barometric pressure is decreased by half.



The barometric pressure readings are usually high in low altitudes due to the high molecules' density above the area. The Dead Sea is the lowest point on Earth. It is located over 400 m below sea level. It is known that the atmospheric pressure there is very high.

Procedure:

1. ***Press*** on the button on the upper left side of the Panda screen and pick the ***Barometer*** option (if it is not already selected).

2. ***Press*** on the button on the upper right side of the screen and then ***press*** on ***kPa***.

3. ***Check*** the barometric pressure where you at in kPa units (kilopascal = 1,000 pascal).

4. ***Press*** on the button on the upper left side of the Panda screen and choose ***Altitude***.

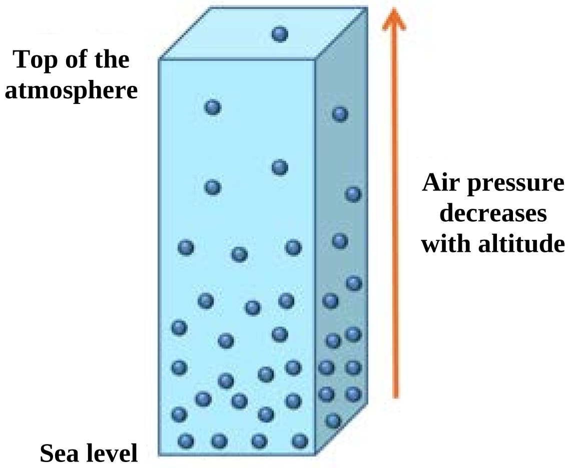
5. ***Check*** the sea level where you at in meters.

6. ***Measure*** the barometric pressure in 3 different floors of a building. ***Write*** the results in the following table.

Barometric pressure and altitude for each floor			
Floor		**Barometric pressure (in kPa)**	**Altitude (in m)**
Ground/First floor			
Second floor			
Top floor			

Discussion during the experiment

- What floor had the highest barometric pressure?
- What floor had the lowest barometric pressure?
- The following image represents the Earth's air pressure. The bottom of the image shows the air pressure at sea level. Does the image match your results? Explain.



- At a high altitude it is harder for people to breathe. Can you explain this phenomenon?
- Guess the measured air pressure on a higher floor. Can you guess the air pressure on the 100^{th} floor?

Summary questions:

1. Plot the anticipated barometric pressure and altitude graph while climbing a hill/mountain.

   If, by any change, you are going on a field trip, take the Panda with you and check if the graph from step 1 is similar to the graph after the measurement.

2. Check online what is the barometric pressure along the shores of the Dead Sea and on top of mount Everest.

3. Which parameters also affect the barometric pressure except altitude?

Summary and more to know

Air pressure:

Air has substance and it puts pressure on everything it touches. This is called air pressure.

When we press the vacuum hook or plunger to a wall, we take the air out. The air pressure inside goes down and that is what holds the hook to the wall.

At sea level there is a high concentration of air molecules, meaning a high air pressure. At the top of a building or a hill there are fewer air molecules, meaning a lower air pressure. The higher you climb, the lower the air pressure.

Evaluating changes in air pressure helps to predict the weather. When the measured air pressure is lower than the norm, it means that the weather will be cloudy, windy and rainy. When the measured air pressure is higher than the norm, it means fair and calm weather.

Altitude:

Altitude is the height of a point or an object in relation to sea level.

Altitude is estimated from air pressure measurements, and this is the reason why the calculation of altitude may not be accurate and may change depending on the weather.

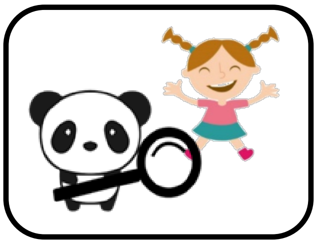
Measuring air pressure using PANDA:

The most common pressure units are Pascal (Pa), kilopascal (kPa), megapascal (mPa), psi (pound per square inch), torr (mmHg – millimeter of mercury), atm (atmosphere pressure) and Bar.

Blaise Pascal:

Blaise Pascal (1623-1662) was a French mathematician, physicist and philosopher who dealt with varied subjects. Pascal made important contributions to the study of fluids and clarified the concepts of pressure and vacuum.

Experiment 2.5 – The Physics of Jumping



Objectives:

- To examine how the acceleration changes while jumping up and down.
- To analyze the graph with the help of sound intensity levels (during the landing of the feet).

Modules and Sensors:

- PC + Panda application (if possible)
- PANDA multi-sensor

Introduction:

Acceleration is the rate at which an object changes its velocity.

The acceleration is positive if an object increases its speed, and negative if an object decreases its speed.

The acceleration of an object which travels in a fixed speed or standstill is 0.

The acceleration units are m/s^2 (square meter per second).

When force is activated on an object, it changes its acceleration.

The acceleration is in a direct relation to the force activated on an object.

The acceleration sensor measures the force activated on the Panda and translate it into acceleration.

The Earth's gravity affects all objects.

When an object is dropped, it drops in free fall (due only to the Earth's gravity).

The gravity affects it all the time, thus it increases it acceleration at a rate of 9.8 square meter per second.

The gravity also affects an object when it is held in your hand, placed on a table or on the floor, and its acceleration is 0.

This is why when the Panda is not moving and is facing upwards, the Z reading is 9.8 m/s^2.

The accelerations measured by the Z axis will refer to this initial value.

This initial value can be reset by the **Offset** button.

In this experiment you will measure sound and acceleration while jumping up and down. The sound level graph will help analyze the acceleration graph.

Procedure:

Experiment setup

1. It is recommended to wear sports shoes for this experiment.

Do not conduct this experiment if you have any physiological health issues.

Settings

2. ***Press*** on the button on the upper left side of the screen.

3. ***Use*** the ***arrows*** to select the ***Acceleration sensor***.

4. ***Press*** on the button and ***choose*** the ***Z axis***.

5. ***Make sure*** that the Panda's screen is facing up (on the table), ***press again*** on the button, and then ***press*** on the ***Offset*** button to offset the sensor's acceleration to ***0 m/s^2***.

6. ***Press*** on the ***Record*** button.

7. ***Set*** the duration to 5 seconds using the ***arrows***.

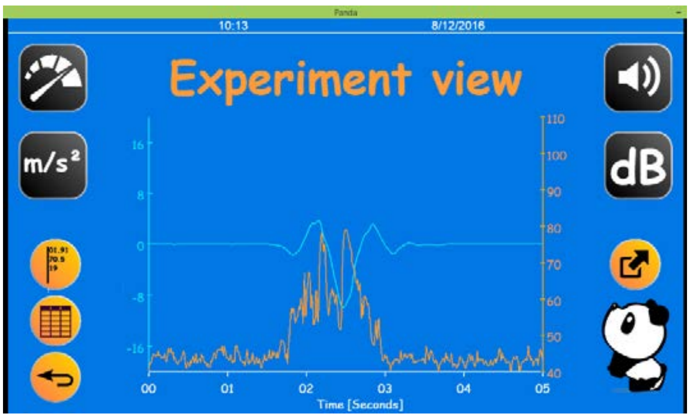
8. ***Press*** on the ***Add sensor*** button on the upper right side of the screen.

9. ***Select*** the ***Sound sensor***.

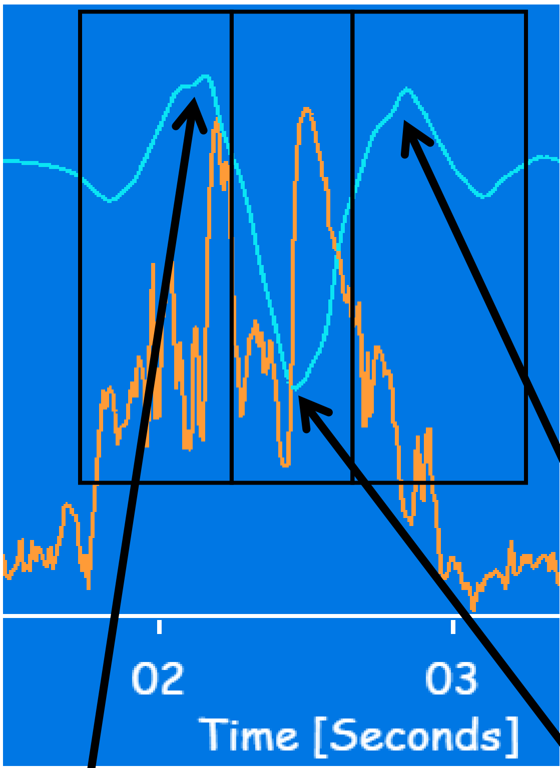
Testing and measurements

10. ***Press*** on the ***Record***  button to start the measurement.
11. ***Hold*** the Panda with its screen facing up, and ***jump up and down*** once.
12. You should see the sound and acceleration graphs together.
13. Your graph should be similar to the following:

14. If possible, ***connect*** the Panda to a PC, using the USB cable that comes with the Panda.
15. ***Open*** the Panda application (can be found in the NeuLog website).
16. ***Press*** on the ***Upload***  button and ***select*** the last experiment.



Here is the zoom of the graph:



What is the position of the student at this point?

The student gets ready to jump while lowering down the Panda. The acceleration is negative while the velocity is increasing, then the velocity is decreasing (to the same direction) so the acceleration is positive. At the end of this step the feet push against the floor, which makes the first sound.

The student is in the air with negative acceleration. You can see the next sound when his feet hit the floor.

17. ***Copy*** the Panda screens to your notebook with explanations.

Summary questions:

1. Analyze the third part of the graph according to what you learned about acceleration and according to the movements during the jump.

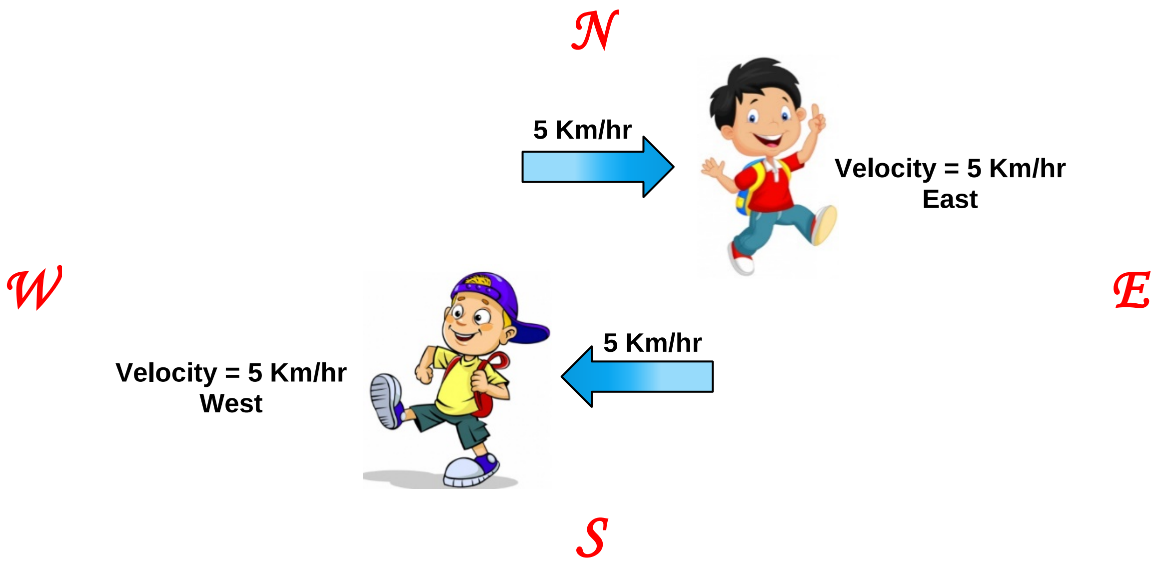
2. Does the sound sensor data correlate with the acceleration sensor data? Explain.

3. Compare your graph to other students' graphs.

Summary and more to know

Velocity and acceleration:

Velocity is the speed of an object plus its direction.



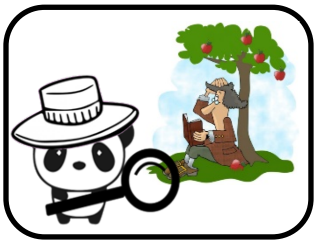
Acceleration is the rate of a change in the velocity of an object.

An object that is accelerating is an object that is speeding up. An object that is decelerating is an object that is slowing down.

Use the PANDA to measure acceleration in a car, a roller coaster or even when jumping up and down, to uncover interesting results.

Next time you run, think about your acceleration, and how does it change when you start to speed up, and when you slow down.

Experiment 2.6 – Gravity and Motion



Objectives:

- To understand what is gravity.
- To investigate the change in the Panda's acceleration while it falls on a pillow.

Modules and Sensors:

- PANDA multi-sensor

Materials:

- A pillow or a couch

Introduction:

Gravity is the force that makes objects fall down towards the Earth. Every object in the universe that has a mass exerts a gravitational pull on every other mass. The size of the pull depends on the masses of the objects. Objects with a very large mass, like the Earth, have a very impressive gravitational pull. The Earth's gravitational force accelerates objects when they fall. It constantly pulls, and the objects constantly speed up.

In this experiment you will measure the acceleration of the Panda while it falls on a pillow. This will demonstrate the Earth's gravitational pull on the Panda.

Procedure:

Experiment setup

1. ***Put*** a large pillow on your lap, or ***sit*** on a couch.

> **It is very important to drop the Panda from a very short distance (up to 60 cm) and only on a very soft surface like a pillow or a couch! A teacher should be near you while you are performing this experiment. There is an option that the teacher will perform the experiment and demonstrate to the students. Do not drop the Panda on the floor!**

Settings

2. ***Press*** on the button on the upper left side of the screen.

3. ***Use*** the ***arrows*** to select the ***Acceleration sensor***.

4. ***Press*** on the m/s² button.

5. ***Change*** the range to ***Z axis***.

6. ***Press*** on the m/s² button again.

7. ***Make sure*** that the Panda's screen is facing up (on the table) and ***press*** on the ***Offset*** button to offset the sensor's acceleration to ***0*** m/s^2.

8. ***Press*** on the ***Record*** button.

9. ***Set*** the duration to 5 seconds using the ***arrows*** .

Testing and measurements

10. ***Press*** on the ***Record***  button to start the measurement.

11. ***Hold*** the Panda with its screen facing up and ***drop*** it (do not throw it) on the pillow or on the couch from a distance of 30 cm.

It is very important to drop the Panda from a very short distance (up to 60 cm) and only on a very soft surface like a pillow or a couch! A teacher should be near you while you are performing this experiment. There is an option that the teacher will perform the experiment and demonstrate to the students. Do not drop the Panda on the floor!

12. Your graph should be similar to the following:

We can see that the acceleration was high (in the negative direction, towards the ground) while the Panda was in the air. After the panda landed on the pillow the acceleration returned to zero. When an object doesn't move its acceleration equals zero.

13. ***Repeat*** the process and ***drop*** the Panda from a distance of 60 cm.

14. ***Copy*** the Panda screens to your notebook with explanations.

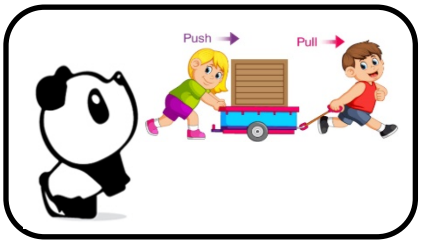
Summary questions:

1. What would happen to the Panda if there wasn't a gravitational pull on it? How would the graph look like?

2. Why is gravity so important to us?

3. Does the maximal negative acceleration differ in various heights?

Experiment 2.7 – Pushing and Pulling a Car



Objectives:

- To investigate how pushing a car can affects its motion.
- To compare different graphs of motion according to the force applied on the car.

Modules and Sensors:

- PANDA multi-sensor

Materials:

- A toy car
- String
- Masking tape or rubber band (may be needed depending on the type of car)

Introduction:

When you push a friend on a swing, you are using a force. Pushing moves something in a specific direction away from the pushing object. The harder the push (the more force applied), the further the item goes. A pull would be a force that brings the object closer, rather than farther. An example of a pulling force is if a rope is attached to an object and a person uses that rope to bring the object closer to them.

In this experiment, you will place the Panda on a toy car, then pull and push the car and watch how the acceleration (change in velocity) of the car varies according to the type of motion and the amount of force.

Procedure:

Experiment setup

1. ***Place*** the Panda on the toy car in the best position according to the car. This position will affect the range you will choose in the next step.

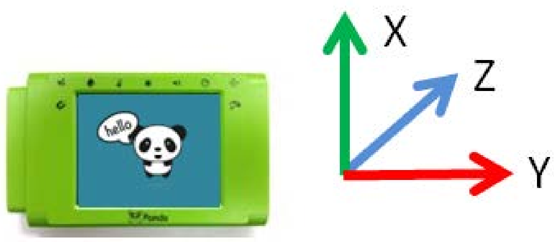
2. If needed, ***tape*** the Panda to the car with masking tape or rubber bands.

Settings

3. ***Press*** on button on the upper left side of the screen.

4. ***Use*** the ***arrows*** to select the ***Acceleration sensor***.

5. ***Press*** on the button.



6. ***Choose*** the ***Y axis***.

7. ***Press*** on the ***Record*** button.

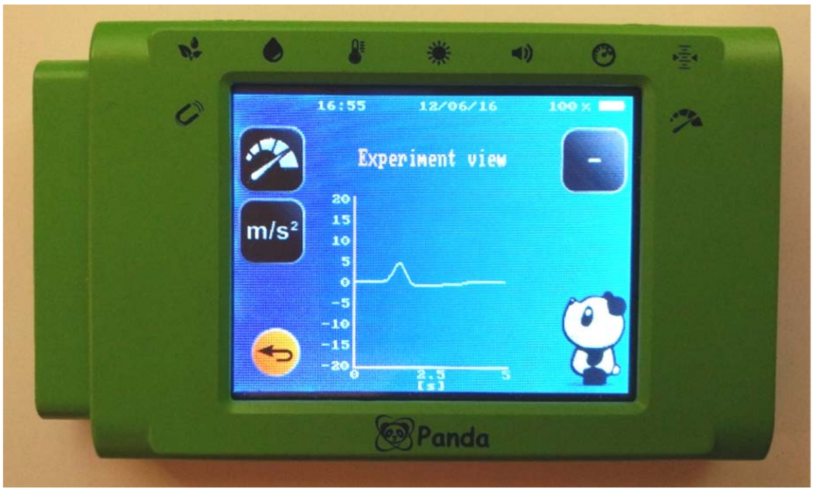
8. ***Set*** the duration to 5 seconds using the ***arrows*** .

Testing and measurements

9. While the Panda is on the cart in the correct position (as specified in step 1), ***press*** on the ***Record***  button to start the measurement.

10. Immediately, ***push*** the car away from you.

11. Your graph should be similar to the following (the graph can look different between different types of cars and the friction with the floor):



We can see that the acceleration (the change in velocity) was rising when the car was pushed and gained speed. Then the acceleration decreased because we let go of the car and it started to slow down (still moving to the same direction). After that it reached zero again because the car stopped moving.

12. ***Draw*** your graph in the table in step 14.

13. ***Repeat*** this experiment but change the amount of force applied on the car while you push (for example, pushing harder than before). ***Draw*** the graph you got in the table in step 14.

14. ***Repeat*** the experiment but now ***use*** a string to pull the car. After that, ***use*** different amounts of force to pull the car and repeat the measurement. ***Draw*** your graphs in the following table.

	Push	**Pull**
Hard		
Soft		

The graph can be below or above zero; it depends on the direction of motion.

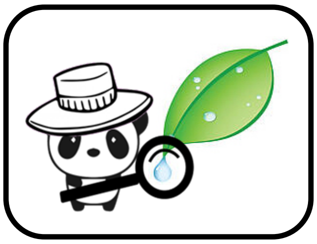
Summary questions:

1. What was the difference in the graphs when you pushed the car harder and softer? Explain.

2. What was the difference in the graphs when you pulled the car harder and softer? Explain.

3. Point out one example of pull and one of push from real life (a different example than what you did in this experiment).

Experiment 2.8 – Relative Humidity and Dew Point



Objectives:

- To learn about relative humidity and dew point.
- To investigate these factors by measuring them inside a container with a moist sponge.

Modules and Sensors:

- PANDA multi-sensor

Materials:

- Plastic container with a partition (that the panda and a sponge can fit in without getting the panda wet).
- Lid for plastic container
- Moist sponge

Introduction:

Relative humidity is the most common way for describing atmospheric moisture, but it does not describe the actual amount of water vapor in the air. Instead, it indicates how close the air is to being saturated. The relative humidity (RH) is the ratio between the amount of water vapor actually in the air and the maximum amount of water vapor required for saturation at that specific temperature (and pressure). When the amount of moisture in the air remains constant and the temperature increases, the relative humidity decreases. Dew point temperature is a better indicator of the amount of moisture in the air.

Dew point temperature is defined as the temperature at which dew begins to form. Dew is the water you may find on the grass or on your car early in the morning (on solid surfaces). The water appears due to the condensation of water vapor in the air. The current dew point will always be lower or equal to the current temperature. A high dew point means there is a high amount of moisture in the air. The tropics are characterized by high dew points while desert regions are characterized by low dew points.

In this experiment, you will measure relative humidity and dew point inside a container with a moist sponge in it.

Procedure:

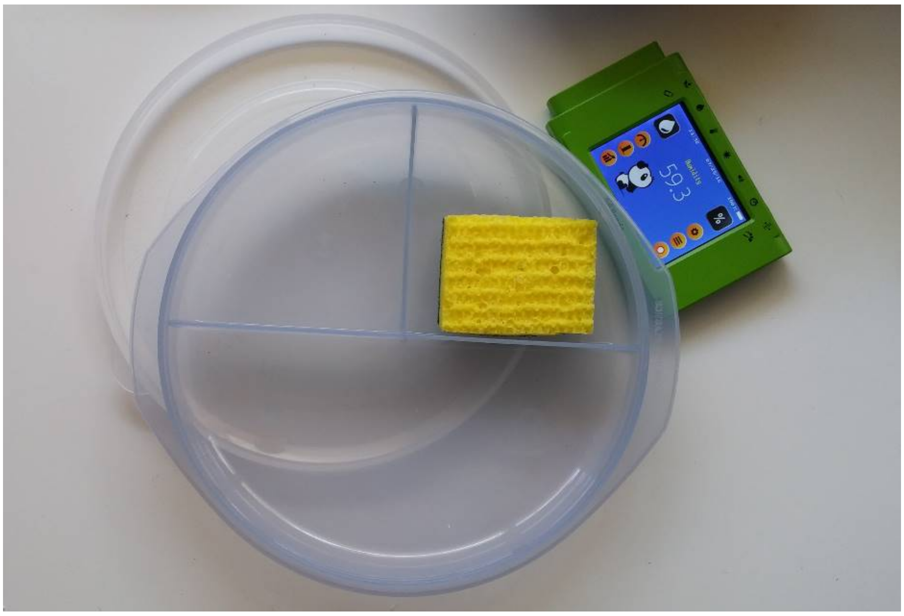
Experiment setup

1. ***Get*** a small sponge wet and then ***squeeze*** some of the water out of it.

2. ***Put*** the sponge inside a container.

3. ***Make sure*** the sponge will not touch the Panda.

It is very important not to get the panda wet!



Settings

4. ***Press*** on the button on the upper left side of the screen.

5. ***Use*** the ***arrows***  to select the ***Humidity sensor***.

6. ***Press*** on the ***Record***  button.

7. ***Set*** the duration to 30 minutes using the ***arrows*** .

8. ***Press*** on the ***Add sensor***  button on the upper right side of the screen.

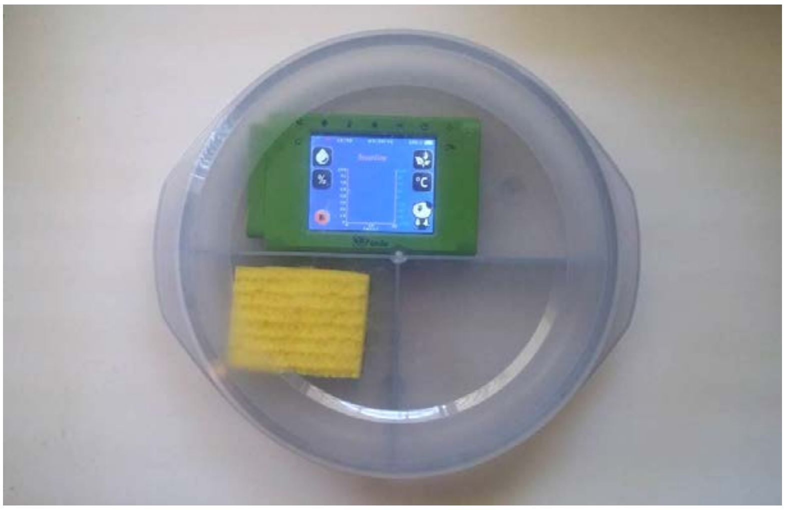
9. ***Select*** the ***Dew point sensor***.

Testing and measurements

10. ***Press*** on the ***Record***  button to start the measurement.

11. Immediately ***insert*** the Panda to a container and ***close*** the lid.

It is very important not to get the panda wet!



12. ***Wait*** for half an hour until the end of the experiment.

13. Your graph should be similar to the following:

14. We can see that the relative humidity and dew point both increased during the experiment. The water from the sponge vaporized slowly into the air and made it more humid.

Summary questions (includes challenge experiment):

1. Draw the expected graph (also include the measured part) for a period of two hours.

   Explain.

   If you have more time available, conduct the same experiment (after the relative humidity displayed on the sensor is like it was before the experiment – the relative humidity of the air in the room). For this experiment set the duration to two hours.

It is very important not to get the panda wet!

   Was the graph similar to what you expected? If not, explain what is the difference.

2. In a different scenario, the temperature decreases and moisture in the air remains the same. What will happen to the relative humidity?

   What will happen to the dew point?

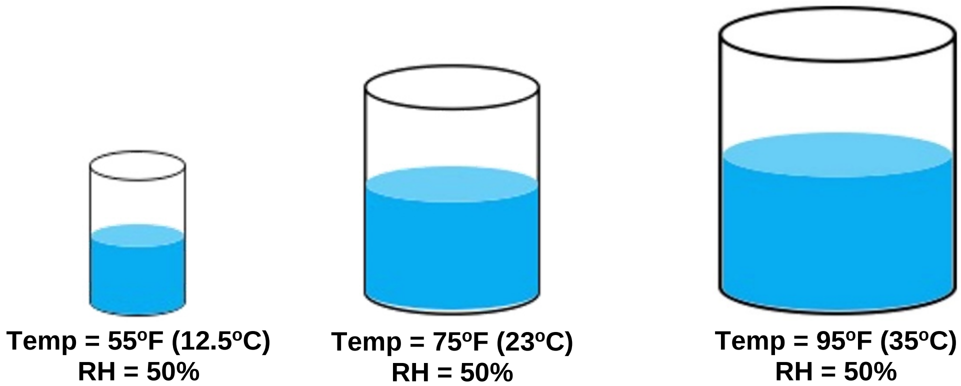
Summary and more to know

The amount of water vapor in the air is described by using the term relative humidity. It is shown as a percentage.

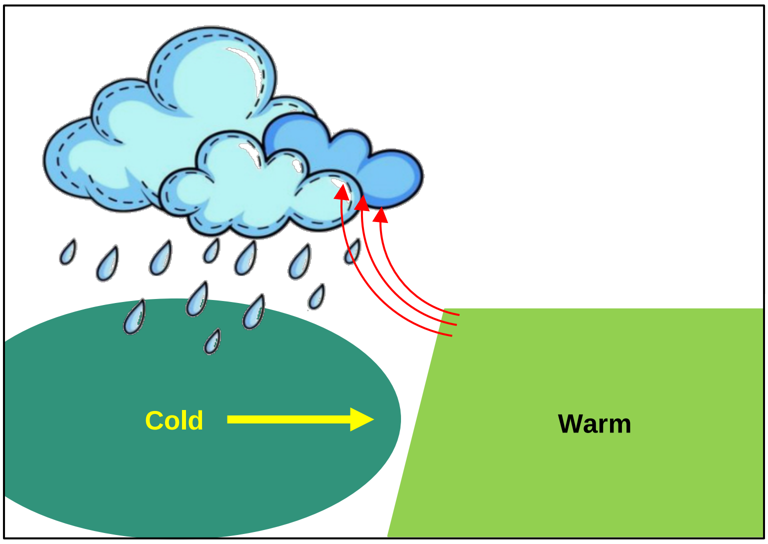
The air's ability to hold water vapor depends on the temperature. As air's temperature gets higher its ability to hold water vapor is higher.

For example, a relative humidity of 50% means that the air is holding one half of the water vapor it can hold in that temperature.

The following picture shows examples of water in the air at different temperatures:



When cold wind reaches an area with saturated air (humid), that air cools down. As it cools down, its ability to hold water vapor decreases, and it begins to discharge water vapor.



That vapor is condensed to water droplets which leads to rain.

We cannot see humidity, only feel it. The lower the humidity is, the more comfortable we feel. When the air is dry and less humid, our skin is dry too. Dry air absorbs sweat fast and cools us down.

High humidity level also affects our hair. It makes it curlier and frizzier.

Tropical forest:

Tropical forests are humid and warm all year-round.

The average temperature in tropical rainforests ranges from 70^o to 85^{o}F (21^o to 30^{o}C).

The humidity levels are also high: 77% to 88% all year round.

That is very humid!

Experiment 2.9 – 360 Degrees of Light

Objectives:

- To learn about the main points of a compass.
- To investigate how light intensity changes at varying directional points during different times of the day.

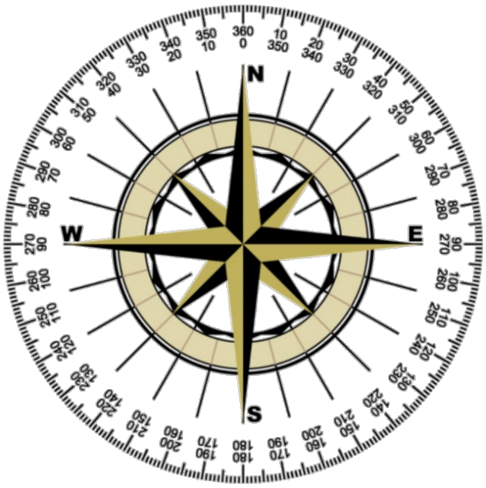
Modules and Sensors:

- PANDA multi-sensor

Introduction:

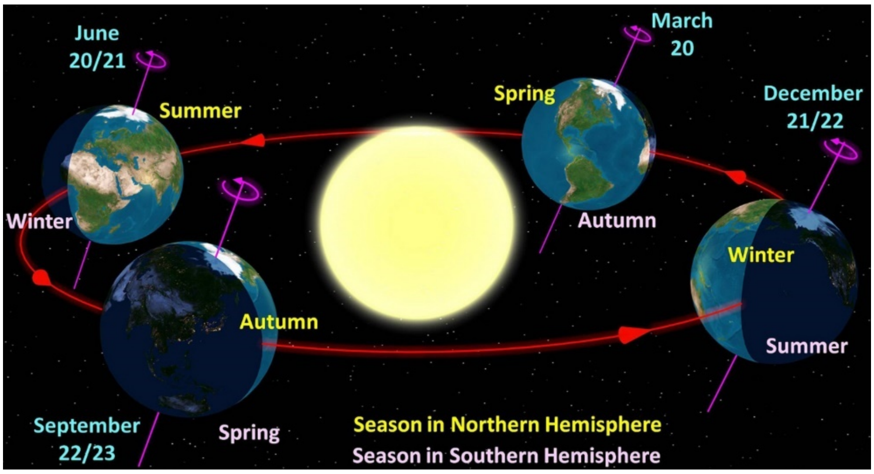
A compass is an instrument containing a magnetized pointer that shows the direction of magnetic north and bearings from it.

The four cardinal points are all 90 degrees apart, with East being at 90 degrees, South at 180 degrees, West at 270 degrees, and North at 360 degrees (or 0 degrees). Identifying the degrees by 45 degrees increments gives us the eight points of direction: North (0 or 360 degrees), North East (45 degrees), East (90 degrees), South East (135 degrees), South (180 degrees), South West (225 degrees), West (270 degrees), and North West (315 degrees).

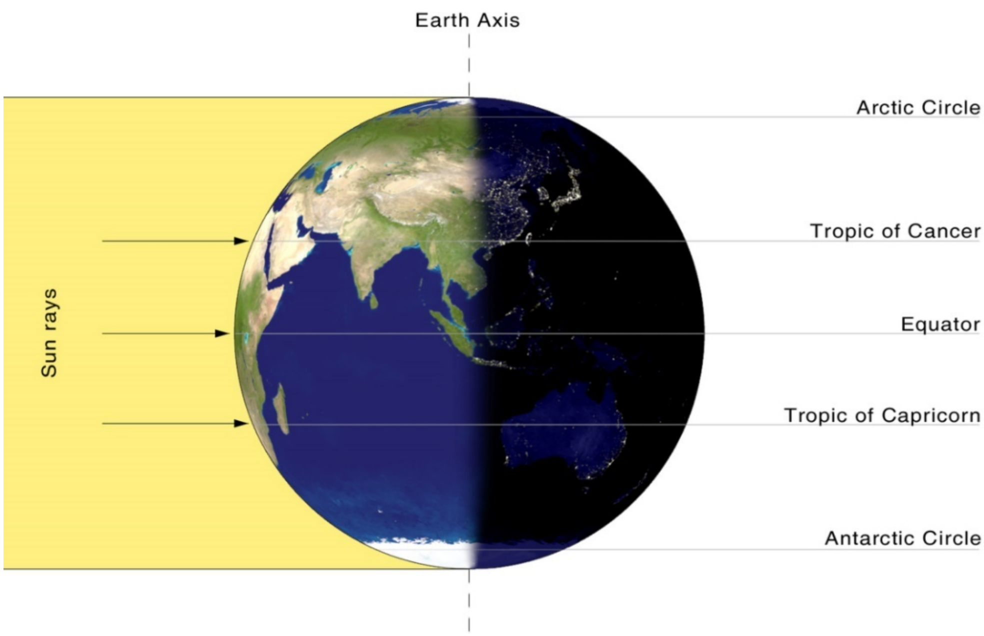


At any given moment, we are all moving at a speed of about 1,674 kilometers per hour, thanks to the Earth's rotation. The Earth's rotation is the amount of time that it takes the Earth to rotate once on its axis. This is accomplished once a day (i.e., every 24 hours). This is the amount of time it takes the Sun to "return" to the same spot in the sky.

The Earth axis in relation to the Sun also changes in the course of a year. This phenomenon causes the seasons of the year.



Illumination of Earth by the Sun at the equinox.



Each day the rising and setting points change slightly. At the summer solstice (the onset of summer), the Sun rises as far to the northeast as it ever does, and sets as far to the northwest. Every day after that, the Sun rises a tiny bit further south.

At the fall equinox, the Sun rises on the east point and sets on the west point. It continues on its journey southward until, at the winter solstice (the onset of winter), the Sun rises as far to the south as it ever does, and sets as far to the southwest.

In this experiment, you will measure the light intensity outdoors at 360 degrees using the internal light and magnetic field sensors. This will be done at different times of the day and, if possible, at different times of the year.

Procedure:

Experiment setup

1. ***Pick*** the hours of the day you plan to measure the light intensity (along with the degrees). It is best to spread the time of measuring throughout the day. Also choose a day that is not cloudy.

2. For the first measurement, ***go outside*** with the Panda to a place with the least amount as possible of buildings or things that can affect the readings. Also keep the panda away from metals and electronic devices.

Settings

3. ***Press*** on the button on the upper left side of the screen.

4. ***Use*** the ***arrows*** to select the ***Light sensor***.

5. ***Press*** on the ***lx*** button on the upper right side of the screen.

6. ***Press*** on the ***0-240000 lx*** button.

7. ***Press*** on the ***Back*** button.

8. ***Press*** on the ***Light sensor*** button.

9. ***Use*** the ***arrows*** to select the ***Magnetic field (magnetic) sensor***.

10. ***Press*** on the ***Range*** button on the upper right side of the screen.

11. ***Press*** on the ***Angle*** button.

12. ***Press*** on the ***Record*** button.

13. ***Set*** the duration to 30 seconds using the ***arrows***.

14. ***Press*** on the ***Add sensor*** button on the upper right side of the screen.

15. ***Select*** the ***Light sensor***.

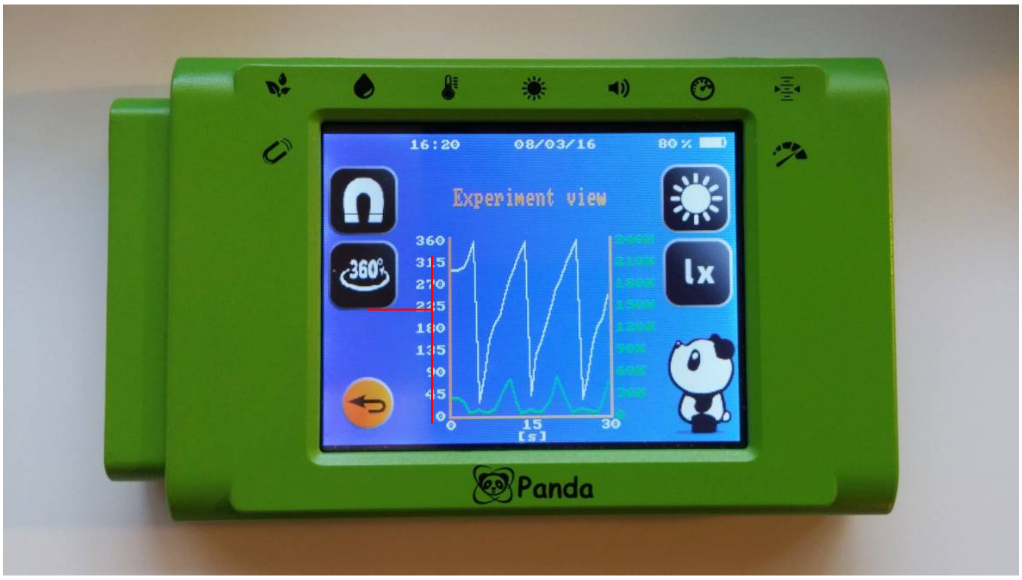
Testing and measurements

16. ***Point*** the sensor horizontally to the ground. The measuring part is on the upper side of the panda (next to the icons).

17. ***Press*** on the ***Record***  button to start the measurement.

18. Immediately ***turn around slowly*** until the 30 seconds are over and the experiment is finished.

19. This experiment was conducted at 3 pm in the beginning of August. Notice that red lines were added on the photo to show the degree in which the light intensity was the highest.



20. We can see that on the sample experiment, the highest light intensity was at slightly above 270 degrees, probably around 290 degrees (In order to see the exact value, you can use the Panda application to upload the experiment and put the cursor on the graph). This consists with the introduction data because in summer the sunset will be between North West and West.

21. ***Proceed*** with your experiment throughout the day and fill the following table:

Date: __________

Time of day	Degree in which light intensity was the highest	Which direction fits to this degree according to the figure in the introduction

22. If possible, ***conduct*** this experiment again during a different time of year.

Date: __________

Time of day	Degree in which light intensity was the highest	Which direction fits to this degree according to the figure in the introduction

Summary questions:

1. Analyze your results in terms of: sunrise, sunset, solar noon and their directions according to the figure in the introduction.

2. Are your results fit what you expected according to the time of year? Explain.

Experiment 2.10 – Forms and Sources of Energy

Objectives:

- To learn about different forms of energy and identify energy sources.
- Measure the light intensity and temperature near a LED light bulb.

Modules and Sensors:

- PANDA multi-sensor

Materials:

- A lamp with a LED light bulb (an incandescent light bulb can be used but because it creates a large amount of heat it should be handled very carefully. Do not leave the Panda near an incandescent lamp for extended periods of time as it may over heat).

Introduction:

Energy makes change possible. We use energy to move cars, bake cakes and light our homes.

Scientists define energy as the ability to do work. Modern civilization is possible because people have learned how to use energy for work and learned how to change energy from one form to another.

There are many forms of energy: chemical energy (stored in the bonds of atoms and molecules), mechanical energy (stored in objects by tension, like a compressed spring), nuclear energy (energy stored in the nucleus of an atom), gravitational energy (stored in an object's height), radiant energy (includes visible light, x-rays, gamma rays, and radio waves), thermal energy (heat), motion energy (stored in the movement of objects, like wind), sound (sound is produced when a force causes an object or substance to vibrate) and electrical energy (delivered by tiny particles called electrons that are moving through a wire).

In this experiment we will focus on the energy of light (which is radiant energy) and the energy of heat (thermal energy). We will use a light bulb (LED) as a light and a heat source and measure the temperature and light around it before and after turning it on.

Procedure:

Experiment setup

1. ***Make sure*** you have a lamp that you have access to with a LED light bulb.

Settings

2. ***Press*** on the button on the upper left side of the screen.

3. ***Use*** the ***arrows*** to select the ***Temperature sensor***.

4. If the **°F** button is seen on the upper right side of the screen, ***press*** it and choose ***°C***.

5. ***Press*** on the ***Temperature sensor*** button.

6. ***Use*** the ***arrows*** to select the ***Light sensor***.

7. ***Press*** on the ***lx*** button on the upper right side of the screen.

8. ***Press*** on the ***0-60,000 lx*** button.

9. ***Press*** on the ***Record*** button.

10. ***Set*** the duration to 2 minutes using the ***arrows*** .

11. ***Press*** on the ***Add sensor*** button on the upper right side of the screen.

12. ***Select*** the ***Temperature sensor***. The light and temperature sensors will measure together.

Testing and measurements

13. ***Put*** the Panda next to the light bulb (do not turn it on yet).

14. ***Press*** on the ***Record***  button to start the measurement.

15. ***Wait*** for about 10 seconds and ***turn on*** the lamp. If it is a LED light bulb you can get the Panda very close to the bulb.

If you are using an incandescent light bulb you should place the Panda a few centimeters from the bulb and make sure it does not get too much heat, or you can also conduct a shorter experiment. Be careful not to touch the light bulb with your hand.

16. ***Put*** your hands a few centimeters from the LED bulb and feel the heat.

17. ***Choose*** your desired temperature units – **°C** or **°F**.

18. Your graph should be similar to the following:

19. We can see that after turning on the lamp, the light intensity immediately increased. Fluctuations in the light measurements can occur because of slight movements of the hand during the measurement. The temperature also increased a bit, but that change is a lot slower.

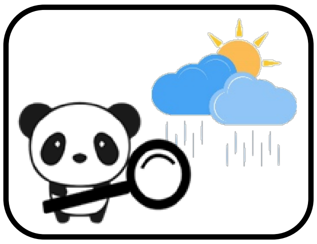
Summary questions:

1. Explain your results.

2. Give other examples for heat source (other than a light bulb). How can it be used?

3. Give other examples for light source (other than a light bulb). How can it be used?

Experiment 2.11 – Weather Measurements



Objectives:

- To learn about weather, temperature and sky conditions.
- To identify basic patterns of weather during an 8 weeks' time frame by measuring temperature and light intensity every week.

Modules and Sensors:

- PANDA multi-sensor

Introduction:

The weather is an important part of our lives; it is the daily state of the atmosphere or air, in a given place. Climate is the average of weather conditions in a specific area over a long period of time (usually over 30 years).

Weather affects comfort, food supply and safety of the people in the area. A meteorologist is a person who studies the weather and can make weather forecasts.

Weather is made up of multiple parameters, including air temperature, atmospheric (barometric) pressure, humidity, precipitation (rain, snow), sky conditions (sunny, cloudy) and wind.

In this experiment you will study the weather conditions in your area over a period of 8 weeks. You will measure light intensity and temperature every week and create a graph from the measured values. You will also write notes about what you feel and what you see.

Procedure:

Experiment setup

1. ***Pick*** the day and hour of the day you plan to measure the light intensity and temperature. Every measurement should take place around the same time of day.

2. ***Select*** a location in the shade to measure temperature and a location that is not shaded to measure light intensity.

Do not use the Panda outside when it is raining. It is important to not get the Panda wet!

Settings

3. ***Press*** on the button on the upper left side of the screen.

4. ***Use*** the ***arrows*** to select the ***Temperature sensor***.

5. ***Choose*** your desired temperature units – **°C** or **°F**.

Testing and measurements

6. ***Go to*** the shaded location where you will measure the temperature.

7. ***Wait until*** the value is stable (does not change) and ***write down*** the value in the following table (according to the example):

Date	Hour	Temperature [°C]	Light intensity [lx]	What do you feel and see? (Is it hot, cold, cloudy, sunny, windy?)
02.05.20	3:15 pm	22.8	6791	Neither hot nor cold (in the sun and shade), a little bit cloudy, no wind

8. ***Press*** on the ***Temperature sensor*** button.

9. ***Use*** the ***arrows*** to select the ***Light sensor***.

10. ***Press*** on the ***lx*** button on the upper right side of the screen.

11. ***Press*** on the ***0-60,000 lx*** button (if you see that you need a higher range during the experiment, ***change*** it to ***0-240,000 lx***).

12. ***Go to*** the location that is not shaded and point the sensor towards the sky (vertical to the ground).

13. ***Fill*** the measured value in the above table (step 7).

14. ***Fill*** in the column of ***"What do you feel and see? (Is it hot, cold, cloudy, sunny, windy?)"***. For instance, you can specify if it was hot/cold in the shade or in the sun, or both. If you notice anything else about the weather, you can write it in the column.

15. ***Repeat*** this measurement every week until the 8 weeks period is over.

Summary questions:

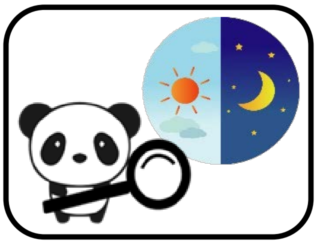
1. Create a graph from your results:

2. Describe how the weather has changed throughout the period you have measured it.

3. Are the results of what you felt (cold/hot) match with what you saw (sunny/cloudy)?

4. Did your results match your local climate?

Experiment 2.12 – Day and Night Sky



Objectives:

- To learn about the changes that occur in the sky throughout the day and night.
- To investigate the light intensity outdoors in a 24-hour cycle.

Modules and Sensors:

- PANDA multi-sensor

Materials:

- USB to wall plug adaptor (used in most cell phone chargers) or alternatively, access to a computer.

Introduction:

The Earth, which is the third planet from the Sun, takes 24 hours to rotate. This is what causes day and night. Daylight is present when the sun is above the horizon at a particular location.

As the Earth rotates, it also revolves around the Sun. It takes the Earth one year or 365.2564 days to completely circle the sun.

The Moon circles the Earth, which takes 27 and a half days. It takes the moon two extra days to come back to the same place because the Earth keeps moving.

In this experiment you will measure the light outdoors during a cycle of 24 hours. After you get the graph you will identify the main parts of it (total dark and light time and the peak of the light intensity).

Procedure:

Experiment setup

1. ***Make sure*** you have access to a window that is exposed to daylight. There should be an electrical outlet near the window or a computer.

Settings

2. ***Connect*** the Panda to a voltage source or to a PC using the included USB cable.

3. ***Press*** on the button on the upper left side of the screen.

4. ***Use*** the ***arrows*** to select the ***Light sensor***.

5. ***Press*** on the ***lx*** button on the upper right side of the screen.

6. ***Press*** on the ***0-6000 lx*** button (if it is a very bright day a higher range may be needed).

7. ***Press*** on the ***Record*** button.

8. ***Set*** the duration to a day (24 hours) using the ***arrows***.

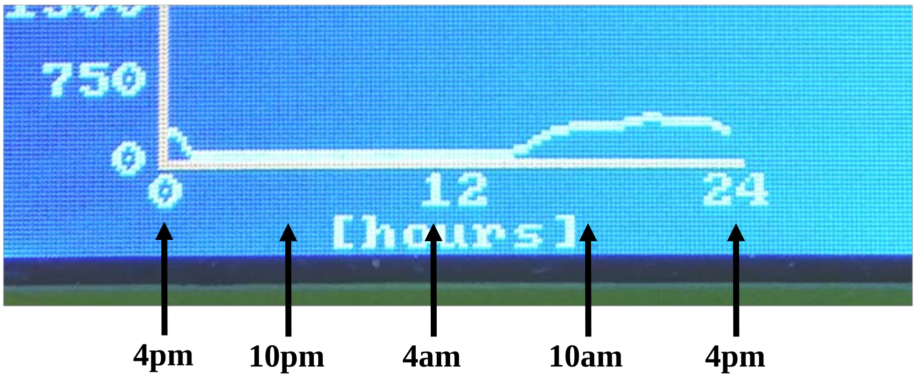
Testing and measurements

9. ***Place*** the sensor on the windowsill so it is facing outside.

10. ***Press*** on the ***Record*** button to start the measurement.

11. ***Check*** the Panda after one day. It might be still measuring if 24 hours are not over yet. If the experiment is finished, you might have to open the experiment using the ***Load experiment*** button. ***Press*** on this button and choose the last experiment.

12. Your results should be similar to the following, depending on the hour of day the experiment had started.



13. We can see that in the sample experiment, after 4pm the light intensity started to decrease, and at around 5pm the light was gone. At around 6am, there was an increase of light intensity that peaked at around noon. After that it started to decrease slowly until around 3pm, when it decreased more rapidly.

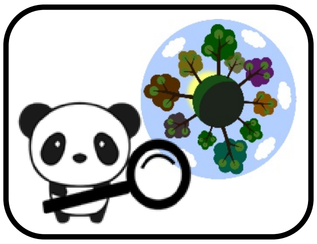
Summary questions:

1. Describe your results (your teacher can help you decide what the correct approximate time for every part is).

2. For how long was the sky lit? For how long was it dark?

3. What is the current season? Does it affect your results?

Experiment 2.13 – Ecology Research Project



Objectives:

- To learn about the ecological principles of biotic and abiotic factors.
- To explore an ecosystem.
- To measure abiotic factors with the Panda (light, dew point, relative humidity), observe the biotic factors (plants, fungus and animals) and find the connection between them.

Modules and Sensors:

- PANDA multi-sensor

Introduction:

An ecosystem is defined as any community of living and non-living things that work together. They do not have clear boundaries, and it can be difficult to see where one ecosystem ends and another begins. The biotic and abiotic factors within the ecosystem are what make it unique.

Biotic factors are all of the living organisms within an ecosystem. These may be plants, animals, fungi, and microorganisms. Abiotic factors are all of the non-living things in an ecosystem.

Biotic and abiotic factors are related to each other in an ecosystem. Abiotic factors are very important because they directly affect how organisms survive.

Abiotic factors can vary among different ecosystems. Examples of abiotic variables are rain, wind, temperature, altitude, soil, pollution, nutrients, pH, types of soil, and sunlight.

For example, watching ants' activity during a month where the temperature drops significantly during this month.

When air temperature drops in the beginning of winter the ant's body temperature drops as well, so much that they become sluggish and therefore hibernate underground. When winter ends, they become active again.

In this experiment, you will explore two ecosystems, measure the abiotic factors with the Panda and observe and count organisms in those environments.

For example, you will sprout beans in saucers on wet beddings (cotton wool, cloth, etc.). These saucers should be places in various conditions of light and temperature.

During this experiment you will count the number of stalks, the number of leaves, the length of the stalks, etc.

Procedure:

Experiment setup

1. ***Decide*** with your teacher on an environment to explore and what are the dates and times of day you will measure in.

   It can be throughout a day, a week, a month or different seasons.

2. ***Arrive*** at the destination.

3. ***Decide*** on the surface area you are going to explore (for example, 2 square meters).

Settings

4. ***Press*** on the button on the upper left side of the screen.

5. ***Use*** the ***arrows*** to select a different sensor.

6. ***Continue*** with your chosen sensor.

Testing and measurements

7. ***Fill out*** the following tables:

Ecosystem name: ___________________________
Date: ___________
Time of day: ____________

Abiotic factors	Result
Light	
Temperature	
Relative humidity	
Dew point	

Biotic factors/name of the organism	Number of organism in the chosen area	Location of these organisms (for example: on the ground, air, on a plant, distant from a plant, etc.)

8. ***Arrive*** at your destination at a different time and ***fill out*** the tables again (this can be done many times).

Ecosystem name: ___________________________
Date: ___________
Time of day: ____________

Abiotic factors	Result
Light	
Temperature	
Relative humidity	
Dew point	

Biotic factors/name of the organism	Number of organism in the chosen area	Location of these organisms (for example: on the ground, air, on a plant, distant from a plant, etc.)

9. At the end of the experiment, ***organize*** all your results in one table, so each line will present all the biotic and abiotic variables for all samples.

Summary questions:

1. How did each of the abiotic factors change during the day / week / month / year?

2. How did the biotic factors change during the day / week / month / year?

3. Find a link between at least one of the abiotic factors to one of the organisms you observed (or not observed in different times). Explain how the factor affected the organism.