Best practices in teaching physics in secondary schools in France

Cité de l'espace educators

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Introduction

In this document, we have sought to distil and present best educational practice recommended to French schools for teaching science, without attempting to make an exhaustive list.

This report focuses particularly on differentiated learning. Of all the educational approaches which a teacher can implement in the classroom, those based on differentiated learning have been identified as among the most beneficial to pupils. It consists in taking account of the diversity of pupils, by implementing methods of work suited to the needs of each person.

The aim is to enable pupils with different aptitudes and needs to reach shared objectives. Its purpose is personalisation of learning so that each pupil makes progress. It also allows teachers to better manage a class by setting up heterogeneous groups, thereby bringing a reassuring and stimulating mood to the class.

Subsequently, other teaching strategies such as error-handling, problem-solving or an experimental approach are presented.

Finally, six activity sheets, setting out the practices described are provided.

I- Differentiated Learning

1- Description

It can be considered that "good practice" focuses on pupils' difficulties and tries to remedy them.
For that:

→ The teacher carries out diagnostic and formative assessments.

Indeed, before and during learning, the teacher investigates the achievements and the needs of each pupil. To obtain a clearer view of each pupil's understanding, abilities and attitudes, the teacher observes the pupils in action, leads discussions or provides questionnaires.

→ The teacher adapts to the difficulties of the pupils.

The main features of this teaching situation are the following.

- Target Skills
  If the same activities are offered to all pupils, understanding, the **required skills**, as well as the expected **performance** can nevertheless be **differentiated**; targeted support can be offered to some pupils.

- Small Group Work
  Working in **heterogeneous groups of pupils**, with potential division of tasks within the group enables each pupil to progress while developing peer support between the pupils.

- Developing Independence
  The independence of pupils is enhanced. **Children progress at their own pace**, according to the difficulties they experience.

- Responding to Difficulties
  The teacher **answers any questions**, **questions and supports** pupils who are struggling. **Occasionally**, **needs-based work-groups** can be set up (pupils then being divided according to identified needs). In this case, the teacher can **differentiate the offered activities,** varying the skills being worked on, the pace, the task, the learning media, the level of guidance, the level of demand, the timescale of learning…

- Remediation
  The teacher must address the difficulties encountered when they have been identified. Remediation can be facilitated by the use of digital resources. Using **explanatory video sequences** enables pupils to find an answer to their questions and increase their knowledge,
- Summarising Time
  Summarising time enables everyone to formulate the **important points of the lesson** and **keep track of them**. It is also a chance to discuss the main difficulties encountered and the solutions implemented to surmount them.

→ The teacher checks progress of pupils' achievement.

A **formative assessment** during learning is indispensable so the teacher can adjust practice. It should be based on explicit success criteria, shared with pupils. In this way, they share in their own assessment and can monitor their progress. The **utilisation of voting boxes** makes this task easier and promotes the teacher's responsiveness.

2- Success Criteria

Here are some criteria which help **assess the effectiveness** of this kind of educational approach:

- Fewer pupils requiring special support;
- Improved academic results;
- A lower dropout rate;
- Improved classroom management, improved pupil motivation.

3- Points to be Aware of

As with any educational approach, this pedagogy presents pitfalls to avoid. Here is a non-exhaustive list:

- Monotony
  It is better to **vary teaching techniques** from one session to another so that pupils do not get tired of them; in fact, working independently in itself will not enable the pupil to process learning and remain motivated.

- Segregation
  Avoid using ability groups where pupils are ranked according to assessment results; it is, however, possible as previously outlined, to bring together, from time to time on a particular point, all pupils with the same needs. It should only be from time to time, where it is a supportive teaching strategy which is not intended to be used in the longer term.

- Division within the class
  The teacher must **preserve the unity of the class group**. This is possible by varying group working time and whole-class working time. In particular, summarising the lesson is best done with the whole class.

- Stagnation
  The teacher must take care to be ambitious for everyone. **Pupils experiencing difficulties must be able to make progress** through progressive exercises, but **successful pupils must also be able to make progress** by carrying out extra work, for example.

- Different objectives
  In order not to marginalise the poorest performing pupils and increase the gap, it is best in the main to offer all pupils a learning situation focusing on **the same learning objectives**, clearly identified by the teacher. Having said that, by adjusting educational and pedagogic parameters, the teacher could design different learning paths which take account of the variation of aptitudes and needs of pupils. For practical reasons, it is important that the number of such pathways is limited. Such pathways would then lead to the same objectives.

4- Heterogeneous Groups: Peer Support

Heterogeneous groups can be managed in two different ways.

→ **Either each pupil has a different role** in the group (for example: the role of "Reporter" for the group or the role of "Demonstrator," etc.). **Skills developed vary according to the roles**, and pupils can be divided into groups according to the learning needs of each person.
Apart from division between thinkers, doers and the uninvolved, two hazards have to be avoided: lack of involvement by the weakest pupils or their involvement being confined to technical or "housekeeping" tasks without intellectual added-value (for example copying the solution the others found).

→ **Or pupils have identical tasks**. The teacher then has to be aware of peer support, goodwill within each group. Good pupils have to help those who are encountering difficulties, and the latter must be able to pose questions freely.

In any case, **regulation** within the group is a social skills objective for pupils to develop, **but it primarily falls to the teacher** to manage the nature of peer interaction.

5- Classroom Organisation

Classroom organisation is a key factor in increased pupil involvement in learning.

Grouping pupils in **small groups of 3 or 4 enables promotion of discussion** and **remediation between pupils**. The teacher must be able to move around the classroom easily, no longer occupying a static frontal position, which is seen as dominant. The teacher becomes a facilitator of pupils' work, and their activities must be under constant research.

Preview of a teaching area for school students at Cité de l'espace

Defining functional zones within the room itself can also contribute to easy identification of the focus of learning skills: documentary research, experimental work, discussion area, for example.

II- Error-Handling

Integral parts of differentiated teaching, **tracing**, **identification** and **resolution of obstacles** and **errors** is both a lever for the pupil to **progress** in learning a reference-point for the teacher to adjust teaching. **Understanding an error contributes to acquisition of the target knowledge**. In this way, error must not be considered a fault on the pupil's part but remedying it makes it a means of better understanding the lesson.

These strategies must be suited to the type of error or obstacle. The pupil's paper trail alone will not be enough to identify errors. Interpreting is better when it is supported by **oral questioning** by the teacher. Where possible, **explanation by the pupil of the path** which led to the error allows the teacher to understand the thought process, as well as **mistaken concepts** which obstruct understanding. **Herein is the key role of the teacher in discussions** with pupils in independent learning.

In this regard, **questioning using voting boxes** can prove very useful if they focus on different **types of error.** That allows pupils to refer to so-called "classic" errors and to remedy potential difficulties concerning the target skills and understanding.

III- Problem-Solving

Problem-solving allows pupils to bring knowledge to bear to respond to a **problem** by **formulating hypotheses**, by proposing a **solution strategy**, and by **checking** results by comparing them with the hypotheses which had been formulated. In this way, they take up a **scientific approach** which they can apply whatever the context.

This type of activity **enables de-contextualisation** of the acquired knowledge and checking conceptual understanding. In fact, pupils are not simply required to retrieve knowledge but to produce a complete rationale which assures us of understanding.

IV- Experimental Approach

Experience improves understanding, motivation and embedding of target understanding and skills of the lesson. Pupils work in groups of 2 or 3. It is interesting to avoid the classic experimental protocol which lists the actions to be carried out without analysis and instead propose **a problem to be solved** which relies on documents and **reflection** by the pupil. As with problem-solving, the pupil must **come up with hypotheses**, try them **experimentally** and **validate** them.

It is also possible and interesting to implement **collaborative teaching sessions**. Each group of pupils conducts **different** but **complementary experiments**. Each experiment provides an answer to a **shared problem**. The objective for groups will particularly be to tell the whole class about the experiments conducted and results obtained.

V- Formative Assessment

1- Mind Mapping

Mind mapping enables **summarising of an overall approach** and clearer analysis of a complex problem. Pupils find it very interesting as it provides a **simplified vision of skills and understanding**. It is also possible for pupils to make their own mind map at the same time collaboratively. This allows the teacher to check that lesson objectives have been achieved.

2- Voting Boxes

The educational system has evolved from the passive pupil to the **active pupil**. Another mutation is under way, the use of **interactive tools**. This educational practice is linked to special equipment allowing immediate knowledge of pupils' responses and take the lesson in a direction **which takes account of their difficulties**. For this, the teacher can use internet-based solutions like **smartphone or computer applications** or **stand-alone voting boxes**.

These enable the teacher:

- To **identify pupils' conceptual representations** about an idea,
- to **work on an error** using **collective remediation** directed by the teacher or peers,
- to check acquisition of **skills and understanding** which have been taught,
- to **adjust teaching to the pupils' pace**, to take account of **difficulties** which are revealed or remain after a work session.

For pupils, voting boxes are a tool for self-assessment relative to the group: it can be **re-assuring** to see that **there are others facing the same difficulties**. It is also an assessment tool for the teacher in terms of practice (development at the end of a sequence). The classroom atmosphere is often more conducive to learning as it allows **learning about learning**.
Poll results are instant and **remediation is immediate**.
It is a very effective formative assessment technique**. Without this resource, formative assessment can be difficult and time-consuming**.

Assessment can lead to a mark if it is a **summative assessment**, at the end of a chapter for example.

Results can be confidential, with only the overall percentages of answers on display. Very simple to implement, this equipment is still expensive (except for interactive use of smartphones or computers). Few establishments are so equipped at the moment, but more and more people want to find out more about or have a go at this new kind of teaching.

VI- Online Resources

1- Online Questionnaires

Schools' internet sites allow teachers to provide online questionnaires. It is possible to retrieve pupils' responses or even, if it is an MCQ, to give it a mark which is directly added to the pupil record. It is also possible to provide **corrected online assessments** which pupils can complete **for self-assessment, independently**. These questionnaires are private initiatives.

2- Online Teaching Video Sequences

On the internet can also be found, particularly on YouTube, **short video sequences** on concepts covered in class. These are private or public initiatives and mostly of good quality. It is possible to use them before, during or after class **in remediation for pupils experiencing difficulties** despite lessons and exercises.

VII- Example Activities to Carry Out in Class

Six educational sequences involving on one or more of the above-mentioned practices have been filmed. Ready for use by teachers, these six activity sheets all present the same stages: teaching objectives, focus skills, interdisciplinarity and understanding developed in each sequence. Moreover, they are sorted according to academic level and duration. Some have an accompanying slideshow for use with classes.

These sequences mainly feature a number of activities; activities organised around four key points: the objective, resources required, how to carry the activity out and guidelines.

The sequences can be sorted by academic level:

For Cycle 3 – CM1-CM2-6th (8-11 years)

- Sequence 1: The Polar Bear's Food-chain
- Sequence 2: Explore the Solar System
- Sequence 3: A celestial object

Cycle 4: 5th – 4th – 3rd (12-15 years)

- Sequence 4: Pareidolias

High School and Further Education (15 years and over)

- Sequence 5: Characteristics of Sound in Habitat
- Sequence 6: Jump Without a Parachute

Sequence 1 – Polar Bear's food Pyramid

Pedagogical intention

Using cubes, the pupils will create the food pyramid of the polar bear. Then, they could understand why oceans' pollution reaches more an animal such as polar bear.

Skills worked

- Perform scientific and technologic methods
- Oral communication
- Team work
- Writing communication

Interdisciplinarity

- Environnement
- Science of life
- Chemistry

Knowledges

- The distribution of living things and the settlement of environments
- To know how to describe a living environment in its various components.
- Interactions of living organisms with each other and with their environment.
- Link the settlement of an environment and the living conditions.
- Modification of the settlement according to the physicochemical conditions of the environment and the seasons.
- Ecosystems (living environment with characteristics and settlement); consequences of changing a physical or biological factor on the ecosystem.
- Biodiversity, a dynamic network.
- Identify issues related to the environment

Title of the activity	Time	Organization
Discover the residents of the ocean with a quiz	15	Work in small groups
Alimentation	5	Whole class
Create a food chain	15	Work in small groups
The food pyramid	10	Work in small groups
The pollution	5	Whole class
Acidification of the ocean	10	Whole class

Description of the sequence

This session was tested with a group of 18 students, aged 8 to 12, in primary and middle school.
6 groups of **3 students** are formed. The duration of the session is one hour in a room organized with islets.
The problem is the same for each group that will therefore perform the same experiments. A written summary will be produced collectively at the end of the session.

Objectives
Classify the planets from the nearest to the farthest of the Sun using temperature as a criterion.

Location in progress
This session is a concept discovery session. These activities make it possible to highlight certain physical properties.

Activity 1 - Discover the residents of the ocean with a quiz

Purpose: Get to know all the main residents categories of the oceans: vegetable plankton, animal plankton, fishes, sea mammals, big predators.
Tools: sheet activity 1
Working methods: In this activity, the pupils work in small groups and the correction is collaborative with the whole class.
Guidelines: Associate each sentence to a resident of the ocean.

Activity 2 – Alimentation

Purpose: La deuxième activité permet de déterminer les raisons de se nourrir
The seconde activity let us determine the reasons to feed.
Working methods: discussion with the whole class.
Guidelines: Listing with the pupils the reason why each living being need to eat to live.
Corrections

- To move,
- to grow,
- to breath,
- to operate every body organs
- to reproduce,
- to maintain a warm temperature inside the body for « warm blood » animals

Activity 3 – Create a food chain

Purpose: to create a food chain
Working methods: In this activity, the pupils work in small groups and the correction is collaborative with the whole class.
Guidelines: Ask the pupils to create a food chain. Put side by side a living being and the one who is eating it.

- Cut and assemble the cubes
- Observe the cubes. Each one represents a living being. Precise what it's eating.
- Ask the pupils to create a food chain. Put side by side a living being and the one who is eating it.
- Interleave arrows « is eaten by » between each living being and its predator.

Activity 4 - The food pyramid

Purpose: to constitute a food pyramid.
Working methods: the pupils work in small groups and the correction is collaborative with the whole class.
Guidelines:
Have students take the seabed image and install all the plant cubes on the sites.
Ask the "herbivores" that feed on plant plankton to eat some of them. (To show that an animal has eaten a vegetable, one puts its cube on it).
Overlay the cubes according to "who eats who", ending with the cube "polar bear".
You got a food pyramid.

Analyze the results and shows that:

- The general form of this construction is a pyramid. The more one climbs into the pyramid, the fewer species there are.
- An animal feeds on several different species.

Activity 5 - The pollution

Purpose: To show the impact of chemical pollution on the food chain.
Tools : sheet activity 5
Working methods : the whole class.
Guidelines : the teacher explains activity sheet 5 to the whole class who can discuss the information provided.

Activity 6 - Acidification of the ocean

Purpose: to show the impact of ocean acidification on the food pyramid. The acidification is increased by increasing CO2 in the atmosphere.
Working methods: the whole class.
Guidelines :
The ocean is in permanent contact with the atmosphere of the Earth. The atmosphere doesn't contain just oxygen. It also contains other gases including carbon dioxide (CO2). This gas is naturally present in the atmosphere but the industries and vehicles produce it in large quantities. On the surface of the ocean, gas exchanges take place and the gases of the atmosphere are found in the water of the ocean. This makes the ocean water more acidic

Consequences: to understand the consequences of acidification of the oceans on its inhabitants, you will have an experiment. This is to soak a shell in a glass filled with household vinegar (which is acidic). Bubbles emerge immediately from the shell. After 24 hours, the shell is practically completely dissolved in the vinegar.

The acid also attacks the carapaces of animals like krill that could disappear. To understand the risks this poses to ocean animals, ask a student to remove the "Krill" cube from the food pyramid (which is collapsing)

SHEET ACTIVITY 1

WHO LIVES IN THE OCEAN ?

Vegetal plankton	●	●	I'm covered of scales and I have fins.
Animal plankton	●	●	I produce living matter
fish	●	●	I'm not the prey of any other animal specie
Sea mammals	●	●	I carry babies in my belly and I nurse them.
Big predators	●	●	I'm composed of very small animals, generally herbivores.

SHEET FOOD CHAIN CONTROLE – Activity 3

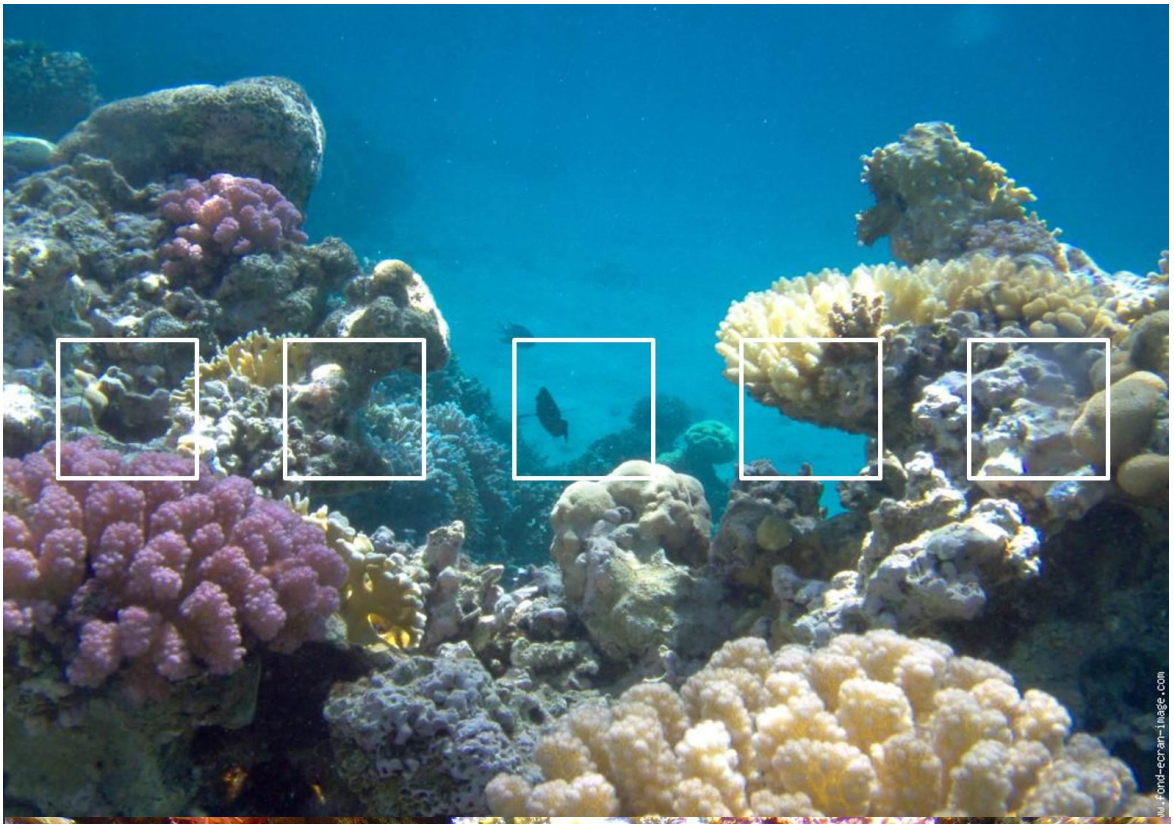
At the base of each chain there is a plant.

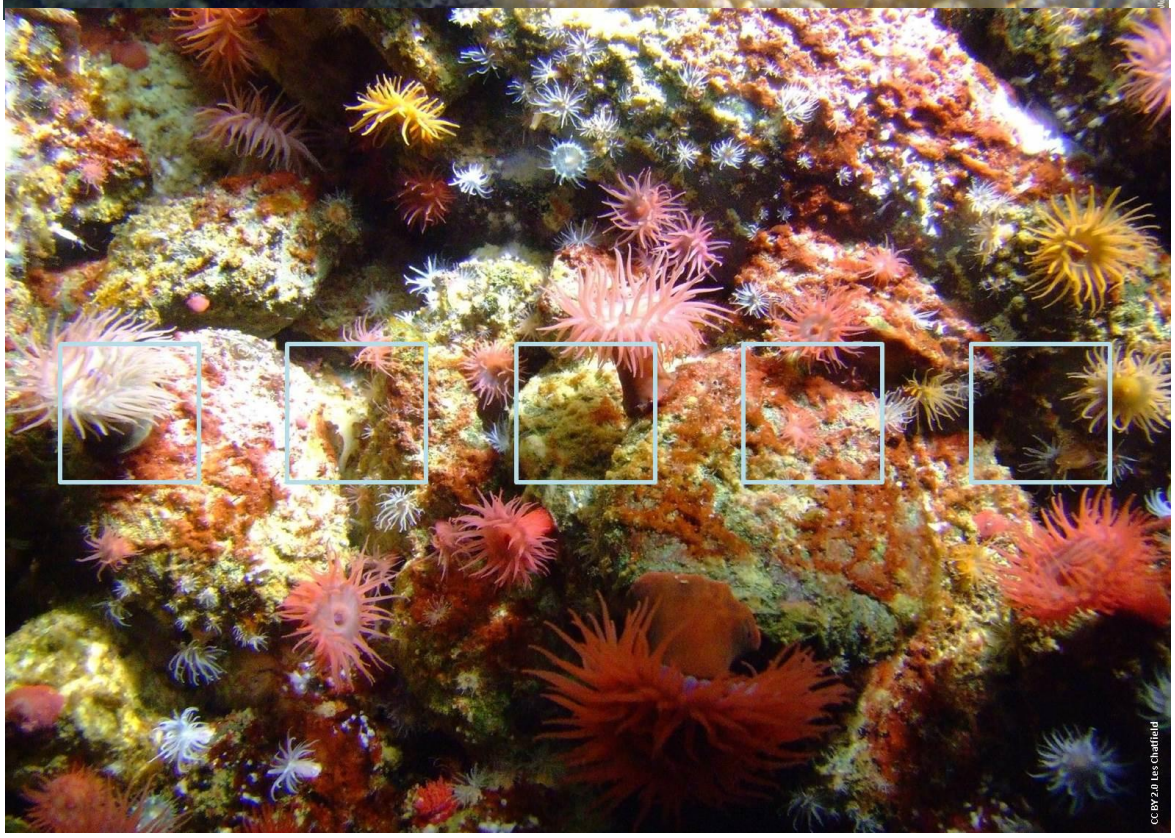
The second link is always an animal; as it feeds on vegetable matter, it is called "herbivore".

The following links consist of animals that feed on animal material; they are called "carnivores":

At the end of the chain, we speak of super prefators.

RESSOURCES - FICHE ACTIVITÉ 4 : *FOND MARIN*





SHEET ACTIVITY 5 -

The marine pollution

We produce a lot of waste and pollutants that sometimes end up in the ocean.

They degrade slowly in the ocean into very small particles. In the ocean, there are 2 nanograms of chemical pollutants per liter of sea water: 2ng / liter

A nanogram is 1000 billion times smaller than the gram!

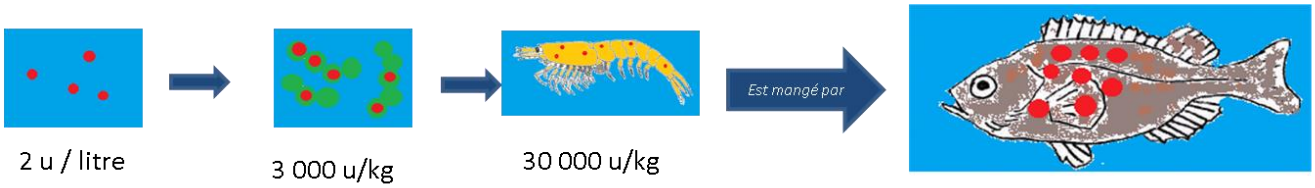
Pollutant particles are ingested by living organisms. (eg, plankton)

the vegetal plankton itself is eaten by herbivorous animals and as these animals eat a lot of plankton, the chemical pollutant is in the concentration of 30,000 units / kg in herbivorous animals

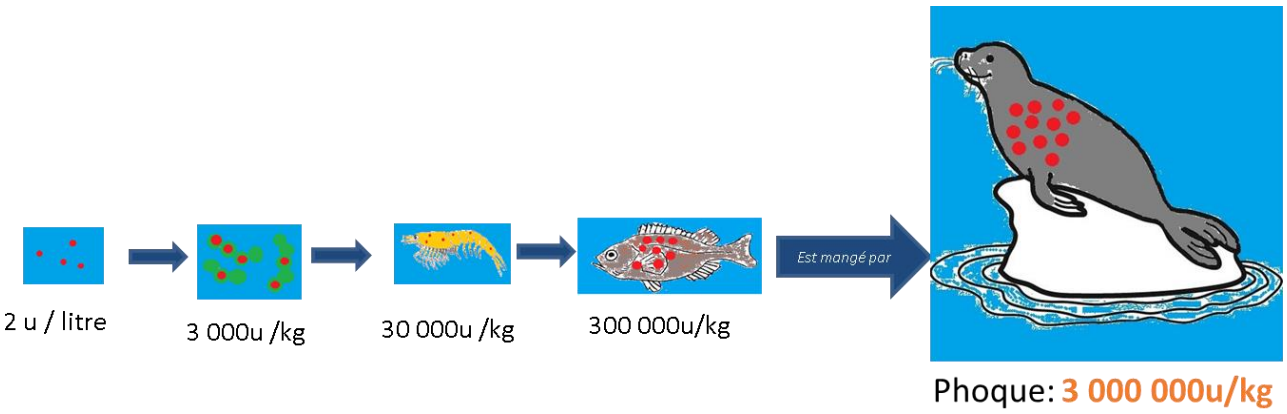
Animal herbivore
30 000 u/kg

And so on. Animal plankton is eaten in large quantities by fish ... whose concentration of chemical pollutants is still increasing.

Seals, by feeding on fish, concentrate chemical pollutants even more.

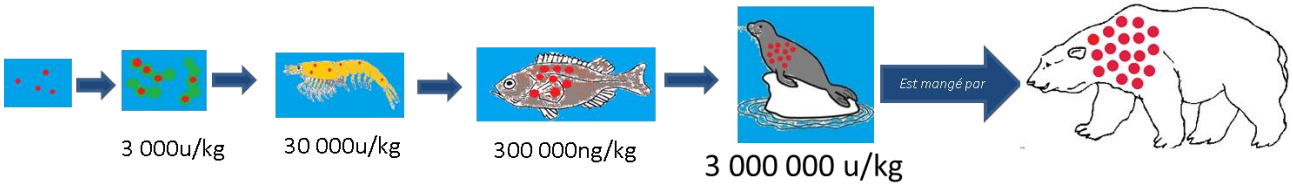


Morue : **300 000 u/kg**



Phoque: **3 000 000u/kg**

Finally, the seal is devoured by the polar bear. Its concentration of chemical pollutants is 10 million units / kg !!!



3 000 000 u/kg

Polar bear: 10 million u / kg !!! The polar bear becomes less resistant to disease.

Sequence 2 – Discovering our Solar System

Pedagogical Intentions

To understand that our star, the Sun, enlightens us but also warms us. The closer a planet is to the Sun, the hotter it is and vice versa.

Introduce the notion of the greenhouse effect that leads to the warming of a planet.

Skills worked

- Practicing scientific and technological approaches
- Oral expression
- Teamwork
- Written expression
- Integer

Interdisciplinarity

- Environment
- Science of life
- Solar system

Knowledge developed in the sequence

- Locate the Earth in the solar system
- characterize the conditions of terrestrial life
- Identify issues related to the environment

Title of the activity	time	Organization
Basic notion	10 minutes	Discussion with the class
Planets and temperature	15 minutes	Groups of 4 pupils
Verification	5 minutes	Whole class
Possibles extention		Whole class

Description of the sequence and objectives

This session was tested with a group of 18 students, aged 8 to 12, in primary and middle school.
6 groups of **3 students** are formed. The duration of the session is one hour in a room organized with islets.
The problem is the same for each group that will therefore perform the same experiments. A written summary will be produced collectively at the end of the session.

Objectives
Classify the planets from the nearest to the farthest of the Sun using temperature as a criterion.

Location in progress
This session is a concept discovery session. These activities make it possible to highlight certain physical properties.

Discovering our solar system

Activity 1 – Basics notions

Purpose: to establish the basics notion about our solar system.

Tool: Attachment 1 - card games

Working method: Presentation of cards to the whole class.

Guidelines: Our solar system includes a single star: the Sun. It is at the center of the Solar System. By burning, it illuminates and warms the planets that revolve around it. Our Solar System includes a star (the Sun) and 8 planets.

Question: Where will the hottest planets be? And the coldest?

Activity 2 - Planets and Temperatures

Purpose: to classify the planets of the solar system in order of temperature.

Tool: Sheet annex 1 - card games + Help Sheet.

Working method: work in groups of 4 pupils.

Guidelines: Place the cards on the table, face temperature visible. Classify them from the hottest planet to the coldest planet. A help sheet (see appendix) can be distributed to them because positive and negative integers must be classified.

Activity 3 - Verification

Tool: Attachment 1 - card games.

Working method: in full class.

Guidelines: Turn all cards over. Thus arranged, they are almost in the same order as in the Solar System. Give them the index card to find the exact order of the planets in the Solar System.

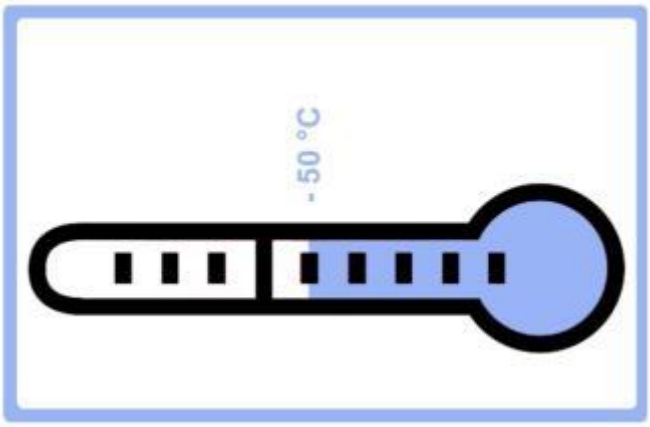
Notes for Teachers

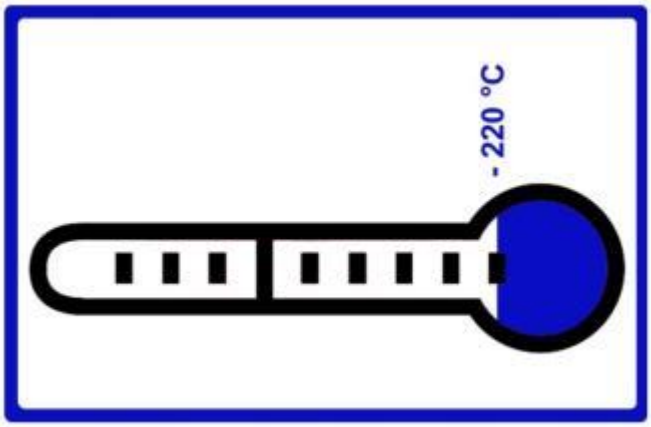
As one might suspect, the hottest planets are near the Sun, and the further away from the Sun the more the planets are cold. The case of Venus is however to be noticed. Although farther from the Sun than Mercury, it is warmer and day and night. It owes its temperature to the composition of its atmosphere, very rich in CO_2, well known to be a greenhouse gas. On Venus, this greenhouse effect has "packed" and the temperature on the surface of Venus no longer drops.

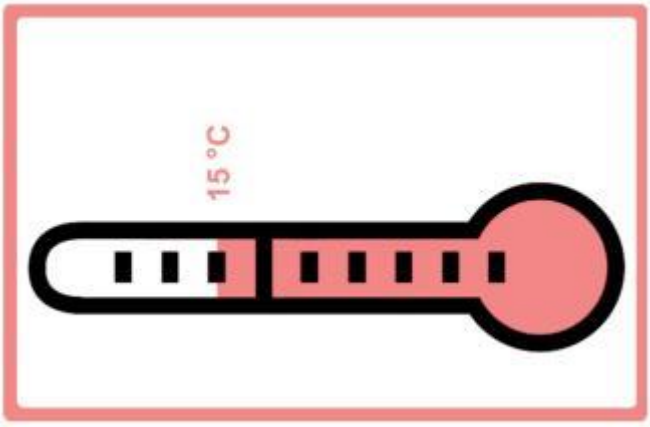
Activity 4 - Possible extensions

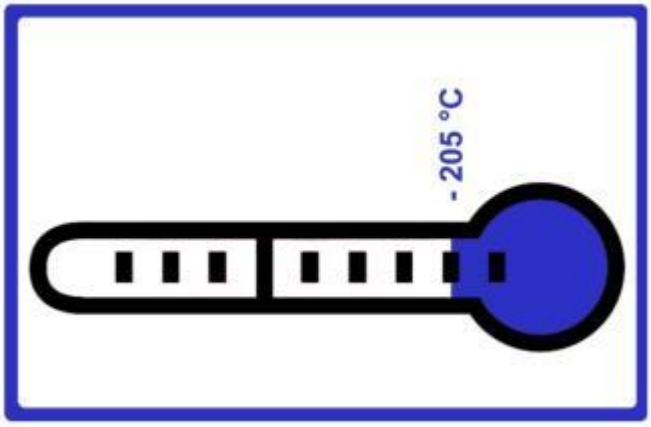
You can then talk to the students about the satellites, add the asteroid belt that is between Mars and Jupiter and the Kuiper Belt that is beyond Neptune. This activity can also be extended by working on the greenhouse effect.

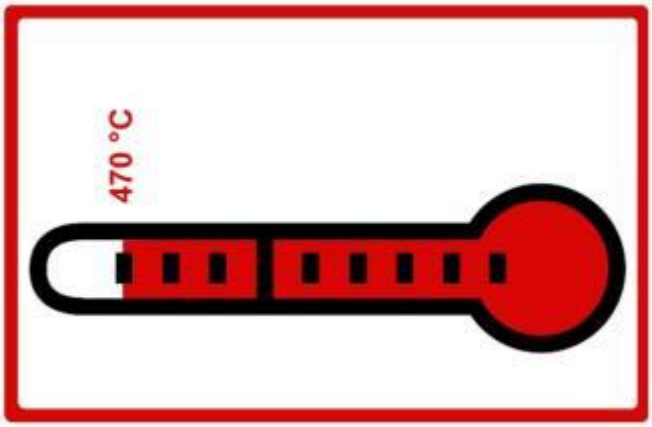
ANNEX CARDS VERSO

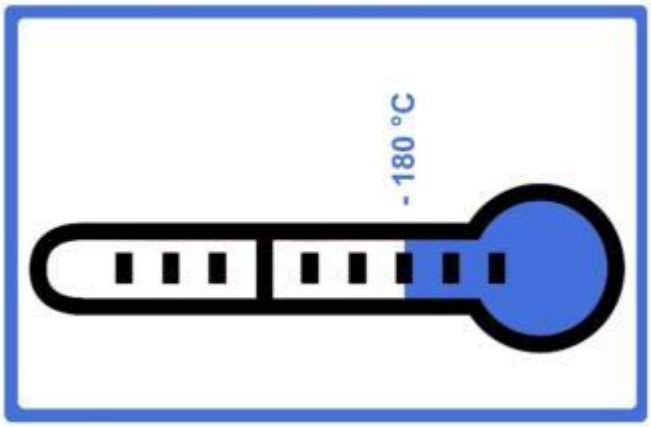


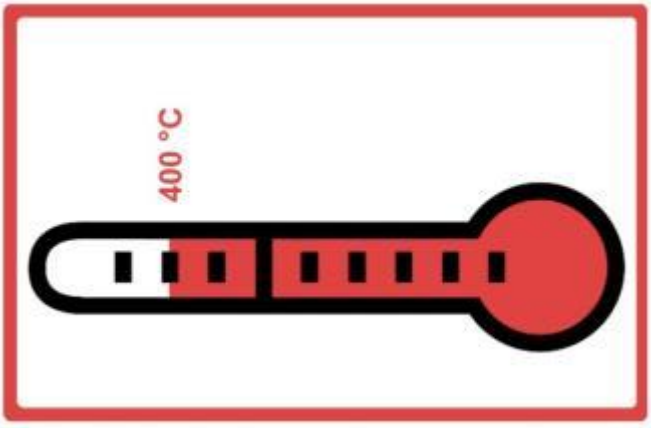


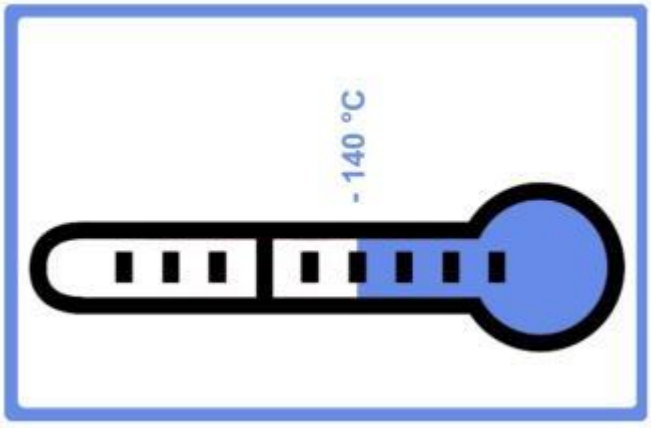




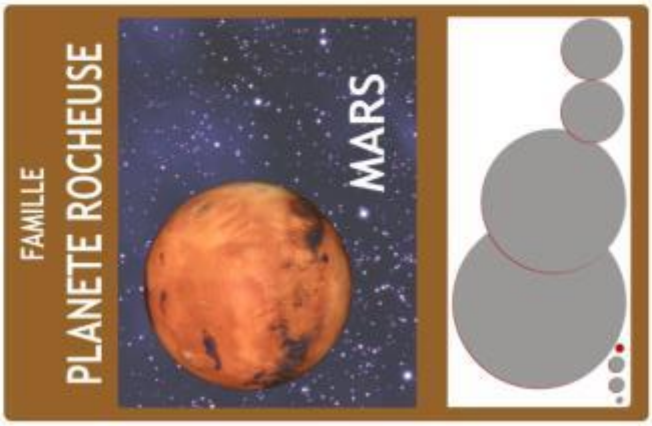


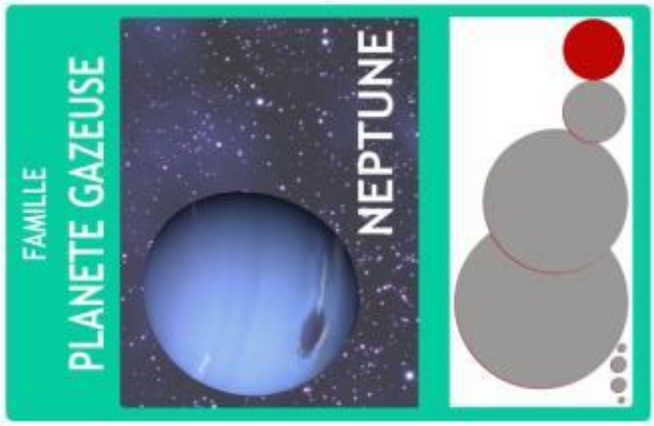


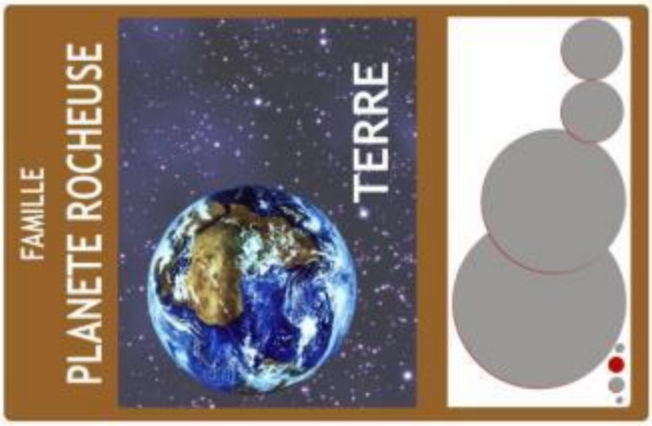


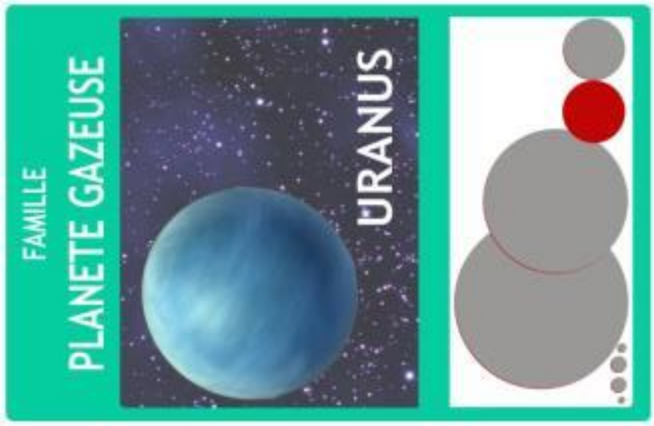


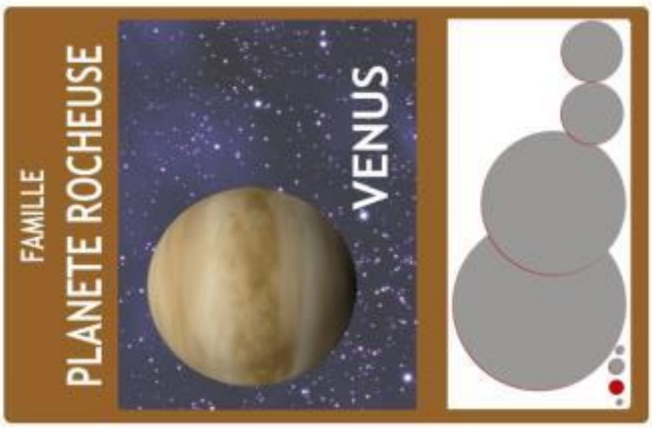
ANNEX CARDS RECTO

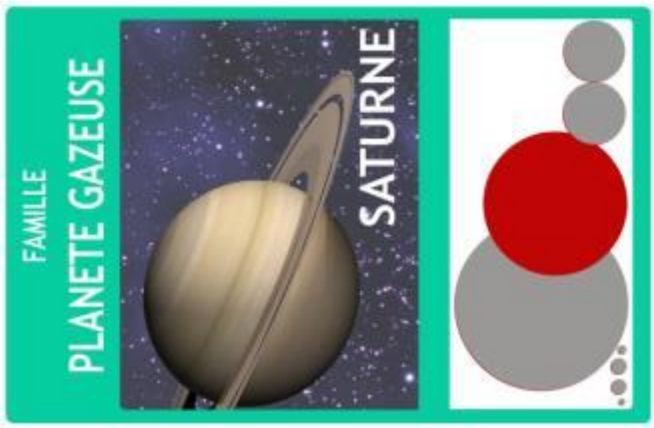


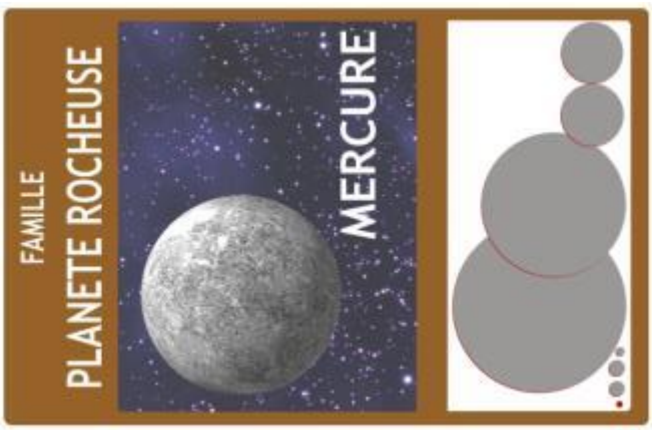


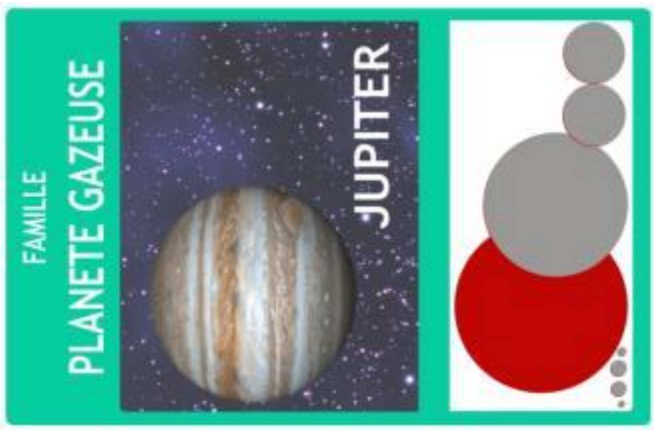












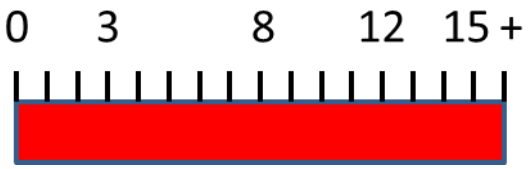
HELPING SHEET for Activity 2

In positive numbers, the farthest the number is from the 0, the greater the number is.

Example:

3 is smaller than 15 (3 <15)

12 is greater than 8 (12> 8)

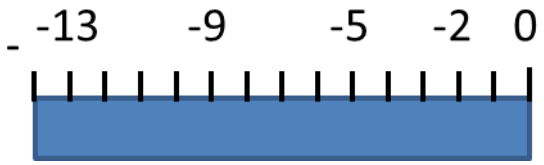


In negative numbers, the farthest the number is from the 0, the smaller the number is.

Example:

-13 is smaller than -9 (-13 <-9)

-2 is greater than -5 (-2> -5)



Use this numerical rule to store the planets from the coldest to the hottest.

CLUE

Venus has an atmosphere that retains the heat of the Sun.
Mercury has no atmosphere to keep the heat.
It is therefore warmer on Venus than on Mercury even if Venus is farther from the Sun.

Distance from Venus to the Sun: 108,000,000 km
Distance from Mercury to the Sun: 58,000,000 km

Sequence 3 – A celestial object approaching

Pedagogical Intentions

The purpose of this resource is to put the student in front of a problem solving situation and to test his capacity to lead an experiment of scientific approach. The session will be conducted in the form of **collaborative pedagogy.**

Skills worked

- Extract information on various media
- To lead a scientific approach
- Establish a protocol
- Teamwork
- Make calculations, draw a line of measurements.

Interdisciplinarity

- Physics
- Chemistry

Knowledge developed in the sequence

- combustion, chemical reaction
- The light
- Phases of the Moon
- The density
- Kinetic energy

Phase	Content	Timing	Organization
1st part	Prerequisite and voting system	10 minutes	Whole Class
2nd part	Follow an experimental protocol	30 minutes	Working in groups
	Analysis of results and communication	10 minutes	Working in groups
3rd part	Make a collective written record	10 minutes	Whole Class

Description of the sequence and objectives

This session was tested with a group of 18 students, from the fourth to the final (students aged 13 to 18) in middle and high school.
6 groups of **3 students** are formed. The **duration of the session** is one hour in a room organized with islets.

The scenario is the same but the problem is different for each group which will thus realize different experiences. A written summary will be produced collectively at the end of the session.

Objectives
All students and the teacher:

- will check the prerequisites by a diagnostic evaluation

Students, into small groups, will have to:

- appropriate the problem,
- carry out experiments and analyze the results,
- answer the problematic,

All students and the teacher:

- will summarize the main concepts encountered during the session.

Location in progress
This session is a concept discovery session. These activities make it possible to highlight certain physical properties.

A celestial object approaching

Part 1: Testing the prerequisites

Duration: 10 minutes

Purpose: To identify students' knowledge of mass, gravitation, combustion
Working mode: whole class with voting box.
Tools: Use of voting boxes.
Description:
The class is informed of the imminence of the arrival of a celestial object.
Here are the questions students must answer:

- This object has a mass of 7000 tons. How does its mass vary by approaching the Earth?
- If this object is made of iron and burns in the atmosphere, how will its mass vary?
- Choose from 3 situations the one that corresponds to the good representation scheme of mutual gravitational attractions.

See the questions at the end of the document.
At the end of this questionnaire and the discussions that accompany the answers, 6 different groups are formed responding to 6 different themes.

Part 2: Experimentation

Duration : 40 minutes

Activity 1 – Experimentation

Purpose: to set up the experiments proposed in autonomy with the digital tablet.
Working method: groups
Tools: digital tablet, experimental devices.
Description: 6 experimental groups consist of:

- **light of an object**: it is about measuring the reflectance of an object at different distances, according to the rotation of the object and its composition,
- **the Moon:** to reconstruct on a model the different phases of the Moon and to understand its movement around the Earth,
- **combustion**: to understand how carbon or iron burns in an atmosphere rich in oxygen which simulates the arrival at very high speed of the body.
- **comet or asteroid:** discover the composition of a comet, its structure, its resistance and compare it to that of an asteroid.
- **damage on Earth:** highlight the influence of mass and speed during an impact,
- **deviations:** to understand the role of an impactor on an object.

Activity 2 - Analyze the results

Purpose: Analyze the results and draw a conclusion.
Working method: groups
Description: Students note the results obtained and provide conclusions that they communicate to all other groups.

Part 3: What do I have to remember?

Duration: 10 minutes

Purpose: make a collective written record by synthesizing the main concepts worked during the session.
Working methods: whole class
Guidelines: All the groups, helped by the teacher, write a summary of the session, including the answer to the problematic and the main notions learned during the session.

RESSOURCES 1st part: Prerequisites

This celestial object is approaching the Earth. It has a mass of 7000 tons. What does its mass become when approaching the Earth?

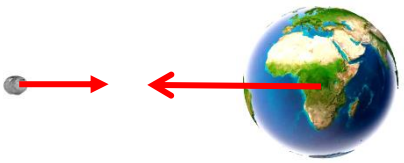
1. It will be a lot smaller.
2. It will be much bigger
3. It won't change
4. I do not know.

If this object is made of iron and burns in the atmosphere, its mass:

1. Will decrease
2. Will increase
3. Won't change
4. I do not know.

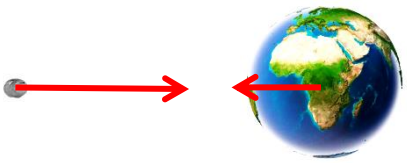
The situations below retranscribe the mutual gravitational attraction between the Earth and the celestial object. Which one is correct?

1.



2.

3.



RESSOURCES 2^{d} part: Experimentation

Team 1 What can we know about the celestial object ?

Material : *lamp, asteroid, black slab rails, light captor.*

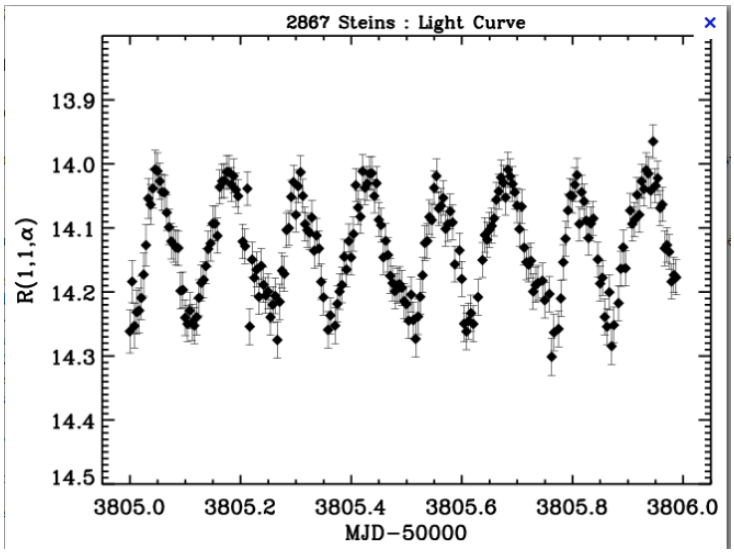
➢ Orientation of the object influence on light

Turn on the light captor. Place the light captor in front of the celestial object.

1. Make it rotate and measure the light intensity.
2. Change the distance with the light captor (closer and further) without rotation, and measure the light intensity.
3. Replace the black celestial object by the white one. Measure the light intensity at the same distance, without rotation.

Which parameters modify the light intensity ?

➢ Rotation influence of the object on light.



http://www.aanda.org/articles/aa/full/2008/33/aa8995-07/img29.gif

Determine the rotation period of the celestial object

Team 2 Can the Moon save us ?

Material : ***lamp, Earth, Moon, mock-up***

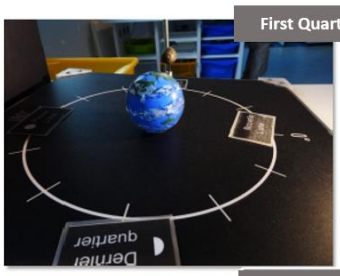
➢ The impact date

Object speed : v = **37,5 km.s^{-1}**
The last measure located the object at **25 920 000 km** from Earth.
The object comes from a direction at **180°** from the Sun.

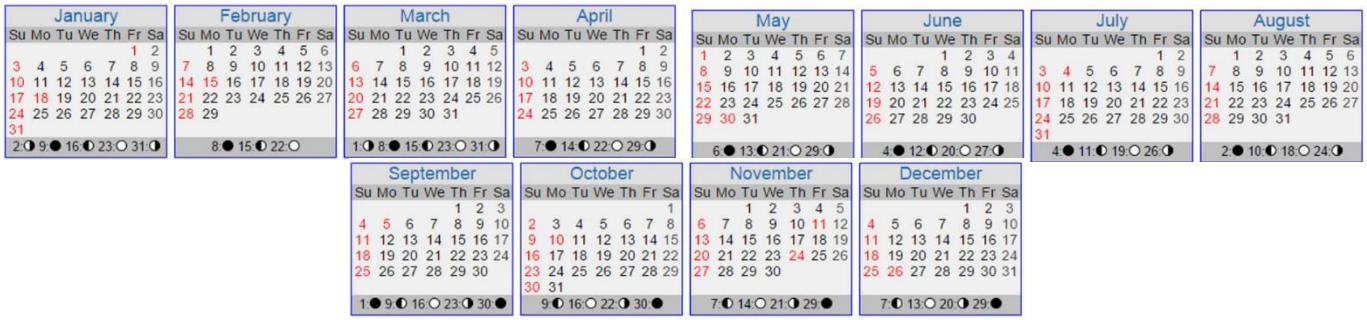
Estimate the impact date

➢ Moon phases

Reproduce on the mock-up each Moon phases (see pictures)



➢ Where will be the Moon ?



Where will the Moon be during the impact ? Can it protect us ?

Team 3 Can atmosphere protect us ?

Material : *video, tablet, precision balance, iron filings, battery*

➢ Combustion of a carbonaceous meteorite

Watch the video.

What happens to the carbonaceous meteorite ?

_____

_____

➢ Combustion of ferrous meteorites.

Put down the cup with the iron filings on the precision balance.

Burn it using the battery.

Observe variation of the mass.

Does iron mass increase after the combustion ? How can you explain it ?
This is the chemical reaction : $Fe_s + O_{2(g)} = Fe_3O_{4(s)}$

_____

_____

Team 4 Comet or asteroid ?

Material : ***Video, meteorite, graduated test tube, precision balance***

➢ Make a comet.

Watch the video.

What is the comet made of ? How can you describe it ?

_____

_____

➢ Compare it with an asteroid.

Calculate the density of the meteorite (asteroid).

Earth rock : 2,5 to 3 g/cm^3

Iron meteorite : 7,8 to 8 g/cm^3

« Chondrite » meteorite : 3,4 to 3,9 g/cm^3

« Achondrite » meteorite : 3,2 to 3,4 g/cm^3

Stony-iron meteorite : 4,3 to 7 g/cm^3

What kind of meteorite (asteroid) is it ? Compare the comet and the meteorite. Which one will be more dangerous for us ?

_____

_____

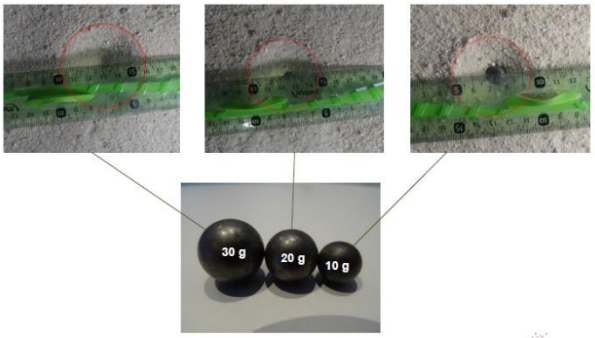
Team 5 *What damages can it cause on Earth ?*

Material : ***Sand, ruler, marbles, container, slow motion video of fall in the water.***

➢ Meteorite impact on the Earth ground

1. Choose one marble. Drop the marble from 3 different heights in the sand. Measure the crater diameter. Mix the sand between 2 measures.

2. Drop the 3 marbles from the same height. Measure the crater diameter. Mix the sand between 2 measures.

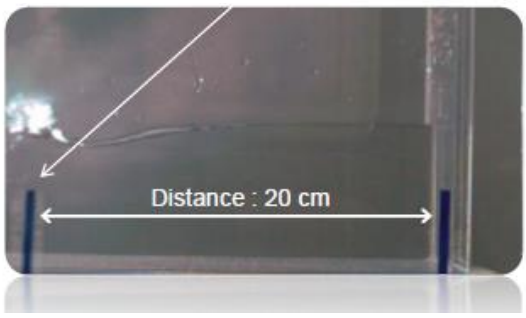


Which parameters affect the craters size ?

➢ Meteorite impact in the oceans

Watch the video.

Wave at the first mark : $t_1 = 0$ ms



Wave at the second mark : $t_2 = 495$ ms

The real speed v_{real} measured in oceans and seas is 200 times higher than in the video in average.

At which distance from the coasts the asteroid should fall so the authorities will have at least two hours to warn the population about the tsunami arrival ?

Team 6 *Can we deviate it ?*

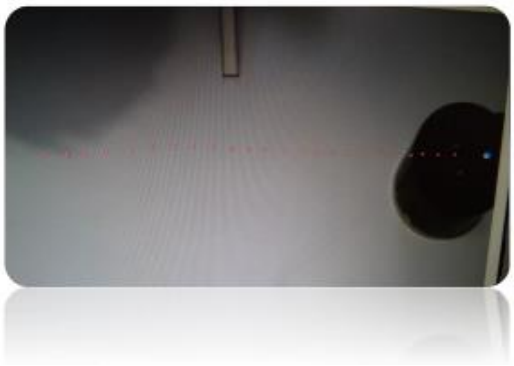
Material : ***Disc, ramps, marbles, speed meter***

➢ Diversions by impact

1. Drop one marble at different speed (different height) and try to deviate the object (disc).

2. Drop different marbles at the same speed (same height) and try to deviate the object (disc).

Low slope : marble speed in m/s before impact.



Strong slope : the same marble speed in m/s before impact.

Sequence 3 – Pareidolies

Pedagogical intention

The purpose of this resource is to put the student in front of a problem solving situation and to test his capacity to lead an experiment of scientific approach.

Skills worked

- Perform scientific and technologic methods
- Oral communication
- Team work
- Writing communication
- Critical Spirit (Zetetic)

Interdisciplinarity

- Science of life
- Chemistry, physics

Knowledges

- Lighting signals
- Distinguish a primary source (lighting object) from a diffusing object.
- Use experimentally the rectilinear propagation of light in the vacuum and light ray model
- Describe the organization of matter in the Universe
- Describe the structure of the Universe and the solar system
- To understand that observable matter has the same nature and obeys to the same laws everywhere
- The solar system, the telluric planets and the gaseous planets

Part	Title of the activity	Timing	Organization
1st part	MCQ on Mars planet with voting system	30 minutes	Whole class
	Documentary research Knowledge	2 hours	Work in small groups
	Presentation of the results	1 hour	Whole class
2nde part	Appropriation	20 minutes	Whole class
	MCQ about strange pictures of Mars	20 minutes	Whole class
	Scientifics questions	1 hour	Work in small groups
	Experimentations	4 hours	Work in small groups
	Analyze of the results	2 hours	Work in small groups
	Oral presentation	1 hour	Whole class
3rd part	What do I have to remember?	1 hour	Whole class

Description of the sequence

Description

This sequence was tested with a group of 24 students, in fourth (students aged 13) in college. The duration is 4 weeks.
Group work is preferred.
Each group will have **different experiences.** He / she will then have to present these experiments orally to communicate the results and conclusions obtained.

Objectives

The student will have to:

- Understand the problematic
- Identify scientific questions and to pick one
- Formulate hypotheses and find experiments to check it
- Communicate orally the results and conclusions he/she gets

Finally, students and teacher together will:

- Answer to the problematic
- Write an abstract of the main notions discovered during the session.

Part 1: Better knowledge of planet Mars and Curiosity

Activity 1 - MCQ on Mars planet with voting system

Purpose: The aim is to identify students 'background about Mars (Atmosphere, distance between Mars and the Sun, Day/Night…) and about the rover Curiosity (cameras, mission…)
Tools: voting system
Working methods: Whole Class
Timing: 30 minutes
Guidelines: Several questions about Mars are asked to the students. They answer on the voting system which immediately displays the results of the whole class. A time of discussion is introduced between the students.
See the questions at Resources at the end of the document

Activity 2- Documentary research Knowledge

Purpose: To have better knowledge about Mars
Tools: student Sheet
Working methods: Small groups
Guidelines: Students will research the main characteristics of the planet Mars (atmosphere, position in the solar system, sunshine, winds, water ...) but also information about the Curiosity mission. Each group appropriates a characteristic, a mission.

Activity 3 - Presentation of the results

Purpose: to know how to communicate its results
Tools: student Sheet
Working methods: Whole Class
Timing: 1 hour
Guidelines: Each group exposes to others the results of their research. An identity card of the planet and the robot Curiosity is realized in the form of a mental map.

2nd part: Strange Pictures – Pareidolies

Activity 4 - Appropriation

Tools: student Sheet
Working methods: Whole Class
Timing: 20 minutes
Guidelines: Reading the subject and the instruction in the whole class.

Activity 5 - MCQ about strange pictures of Mars

Purpose: to know the proportion of people who believe in non-rational explanations of these images.
Tools: voting system, ppt presentation.
Working methods: whole class
Timing: 20 minutes
Guidelines: The voting system can be used again to determine what proportion of the class believes in non-rational explanations for these images. A time of discussion is introduced.
See the questions at Resources at the end of the document

Activity 6 – Scientifics questions

Purpose: To identify the inherent scientific questions.
Working methods: small groups
Timing: 1 hour
Guidelines: Students should formulate hypotheses relied with the scientific questions asked. From these hypotheses, the student will propose an experiment to reproduce a pareidolia.
A helping document is available for students. It is provided only on the basis of the difficulties of the groups. This differentiation of help makes it possible to manage the heterogeneity of the groups.

Activity 7 - Experimentations

Purpose: to carry out experiments highlighting a/or several pareidolia in accordance with the hypothesis formulated.
Working methods: small groups.
Timing: 4 hours
Guidelines: Students have their smartphone to make pictures, lamps, various objects...

Activity 8 - Analyze of the results

Purpose: analyze the results obtained and validate the hypotheses.
Working methods: small groups.
Timing: 2 hours
Guidelines: Students make photos and check the assumptions made. They draw conclusions and draft them.

Activity 9 - Oral presentation

Purpose: to know how to communicate your results
Working methods: whole class
Timing : 1 hour
Guidelines: The pupils present to their classmate the material used, the experiment carried out, and the images obtained. They also present their conclusions based in particular on optical illusions showing the importance of personal interpretation face to the vision of a phenomenon.
All groups end up collectively responding to the problem.

3rd part: What do I have to remember?

Purpose: make a collective written record by synthesizing the main concepts worked during the session.
Working methods: whole class
Timing: 1 hour
Guidelines: All the groups, helped by the teacher, write a summary of the session, including the answer to the problematic and the main notions learned during the session.

STUDENT SHEET

1st Part: Better knowledge of Mars and Curiosity

Documentary research

Split in small groups in order to make a documentary research about main characteristics of Mars. You could

Talk about size of Mars, distance to the Sun, seasons, shifting day/night, composition of Martian Atmosphere, temperature, pressure…

It will be interesting to compare this data to Earth.

Communication

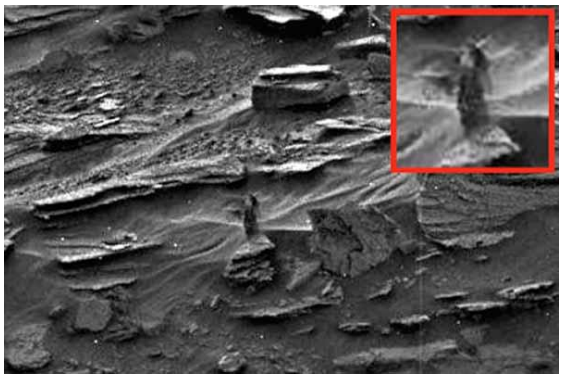
You have to present your results and complete the mind map, ID of Mars.

A prezi presentation can be made

2nd Part : Strange Pictures - Pareidolia.

Problematic

«In the middle of the abundant harvest of photos of the red planet regularly reported by the Curiosity robot, there are sometimes rocks whose shapes tickle our imagination."



Following this article, the journalist seeks to understand the forms observed on Mars thanks to Curiosity,

ILLUSION. *A ghostly woman in a robe, contemplating, in the wind, the desert Martian landscape. This is what Internet users believed to be in one of the many images collected by the exploration robot Curiosity from the surface of the red planet. This picture was taken by Curiosity's Mastcam camera during the 1001st Martian Day of the robot (ground 1001), which corresponds to a shot taken on May 31, 2015. But it is only very recently that this photo made rush social networks*. Extract from a newspaper article-Science and Future August 14, 2015

Instructions

A reporter gives you a mission:

Suggest a scientific explanation to this phenomena and an experiment highlighting a pareidolia.

Write a report explaining it. Be clear and scientifically right. You can use your knowledge about light propagation, shadows and optical illusions.

DOCUMENT ÉLEVE - HELP

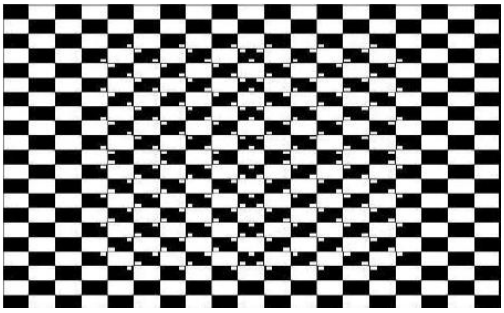
HELP 1: Pareidolia

This phenomenon of identifying a familiar form in a landscape, a cloud, smoke, or an ink stain carries a name. This is called "pareidolia". This reflects the normal process of functioning of our brain that continuously interprets visual information to make sense of it. This woman's shadow is not the first (or last) pareidolia spotted on the surface of the red planet.

Help 2: Optical illusions

- **Curved or straight lines?**

Are the lines straight? Obviously no, and yet ... One can verify that they are with a simple rule!



- **Faces that change their expression?**

Look at this picture of your chair. M. Anger is on the left and Mrs Quiet is on the right.

Now get up and back 3-4 meters ... They've changed places!! The illusion was created by Philippe G.Schyns and Aude Oliva from the University of Glasgow. She suggests that we do not always see what is really before us ...

- **A bar that changes color?**

Look at the bar at the center of this image. Its color appears to vary from a light gray to a dark grey. And yet ... Hide the grey gradient above and below the bar and check for yourself!

Sequence 4 – Sound characteristics in the habitat

Pedagogical intention

The purpose of this resource is to put the student in front of a problem solving situation and thus to approve his/her ability to carry out a scientific approach. The session will be conducted in the form of **collaborative pedagogy.**

Skills worked

- Perform scientific and technologic methods
- Oral communication
- Team work
- Writing communication

Interdisciplinarity

- Science of life
- Physics

Knowledges

- Characteristics of the waves
- Wave properties
- Studying frequency

Part	Content	Timing	Organization
1st part	Brainstorming	30 minutes	Whole class
2nde part	Appropriation	10 minutes	Work in small groups
	Scientifics questions	20 minutes	Whole class
	Experimentations	20 minutes	Work in small groups
	Analyze of the results	10 minutes	Work in small groups
	Communication	20 minutes	Whole class
3rd part	What do I have to remember?	20 minutes	Whole class

Description of the sequence

Description

This session is tested with 12 students of 1st year of technological high school STL (Laboratory Science & Technology) (16 years old).
Each group has **3 students.** The session **lasts 2 hours** in experimental room.
Even so, they all have the **same problematic;** each group will have to make **different experiments.**
Then, the group will have to present these experiences orally to communicate the results and conclusions obtained.

Objectives
All students and the teacher:

- will check the prerequisites by a diagnostic evaluation

The student will have to:

- **Understand** the problematic
- Identify **scientific questions** and to pick one
- Formulate **hypotheses** and find experiments to check it
- Answer to the **problematic**
- **Communicate orally** the results and conclusions he/she gets

Finally, students and teacher together will:

- Write **a synthesis** of the main notions discovered during the session.

Location in progress
This session is the first introduction to the theme. After this session, follow a class session and then a practice session before a final assessment session.

1st Part: Better Knowledge of sound waves

timing : 30 minutes

Activity 1 - Brainstorming about sound waves

Purpose: to identify the knowledge's of the students about sound waves
Working methods: whole class
Guidelines:
The teacher asks to the students what sound means to them. He writes all the ideas on the black board without any comments.

Activity 2 – Numerical animation.

Working methods: whole class
Tool : https://www.youtube.com/watch?v=qNiPibY68I4
Guidelines:
From discussion / brainstorming emerges the notion of vibration of molecules. A digital animation is projected to the whole class and shows the vibrations of molecules step by step.

Activity 3 – Experiments

Working methods: whole class
Tool: student sheet

Guidelines:
This vibration shows a repetitive phenomenon.

- Thank to an oscilloscope, we can observe the sound from a high-speaker to human ear. We observe a sinusoidal wave.
- a sinusoidal is drawn on a paper sheet. The student can measure the period and calculate the frequency.
- the teacher changes the frequency of the sound from the high-speaker. We observe that a variation of the frequency changes the thickness of the sound.
- the teacher changes the intensity of the sound (without touching the frequency). We observe that the amplitude of the signal changes.

From the previous talk comes the idea of propagation of sound in the air.

- A vacuum bell shows that the sound can not go into emptiness.

2nd part: How to protect ourselves from noise?

Duration: 1h10
General Objective: Facing a given problem, the different student groups must make assumptions, propose experimental resolutions, set up experiments, validate the hypotheses from the results obtained and present the conclusions to the rest of the class. Each group will therefore have a different mission, but the problematic is the same for everyone.

Activity 4 – Problematic

Purpose: To assimilate the problem
Tool: student document
Working mode: whole class
Timing: 10 minutes
Guidelines: reading the subject and the instruction with the whole class.

Activity 5 – Scientific Questions

Purpose: To identify the inherent scientific questions
Tool: student document
Working mode: small groups
Timing: 20 minutes
Description
Through a series of group discussions and discussions, students must reach:
- identify the scientific issues to be addressed
- to divide the questions to be dealt with.

Four scientific questions emerge:

- How does the sound vary when moving away from the transmitter?
- How does the sound cross the materials? Does this transmission depend on the frequency?
- How can the sound be reflected on a surface?
- What is the influence of the number of sound transmitters on the overall sound intensity?

Activity 6 - Experimentations

Purpose: to carry out experiments to verify formulated hypotheses.
Working mode: small groups
Timing: 20 minutes

Description: Students must be able to formulate hypotheses and propose experiments to be carried out.
Above all, the teacher presents the sound meter that can be used. The students downloaded an application on their mobile that allows to produce a sound at different frequencies *(Simple tone generator).*
In addition, they are aware of the additional material available (wooden boards, cork, supports ....).
They then propose four experiments and formulate hypotheses for each of them in order to answer the scientific questions:
- Influence of the distance and the angular position on the sound. Students will measure sound at different distances and angles.
- Sound transmission. Students will measure the sound that passes through various materials (wood, polystyrene, foam, metal ...) and different thicknesses.
- Reflection of sound. Students will study the ability of sound to reflect on a surface.
- Influence of the number of transmitters. Students will study the sound emitted by two transmitters and compare it to that of a single transmitter.

Activity 7- Analyze of the results

Purpose: analyze the results obtained and validate the hypotheses.
Working mode: small groups
Timing: 10 minutes
Guidelines :
Students record the measurements and verify the assumptions made. They give conclusions and write them down.

Activity 8 - Oral presentation

Purpose: to know how to communicate your results
Working methods: whole class
Timing: 20 minutes
Purpose: The pupils present to their classmate the material used, the experiment carried out, and the images obtained. They also present their conclusions, using optical illusions, showing the importance of personal interpretation in front of the vision of a phenomenon.
All the groups end up collectively responding to the problem.

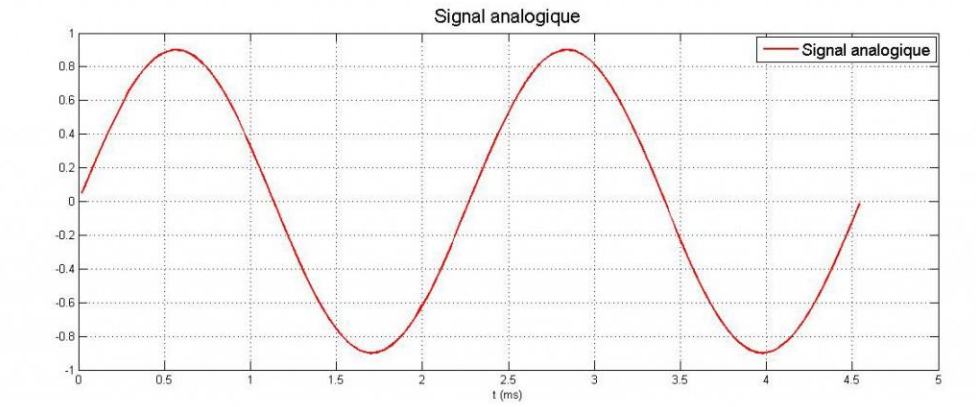
3rd part: What do I have to remember?

Purpose: make a collective written record by synthesizing the main concepts worked during the session.
Working methods: whole class
Timing: 20 minutes
Guidelines: All the groups, helped by the teacher, write a summary of the session, including the answer to the problematic and the main notions learned during the session.

STUDENT SHEET

1st Part: Better Knowledge of sound waves

Experiment: *Observation of a sound signal received by a microphone*.



1. Determine the period of this signal. T = ...
2. Deduct the frequency. F = ...

2nd part: How to protect ourselves from noise?

Among the questions related to the Grand Stade de Lille for which there is no answer yet, there is that of noise nuisance. Opponents, and the state, have argued that acoustic study is lacking. The builder based his studies on an average sound level during a 85 decibels football game, the sound system peaking at 95 decibels. For concerts, the cursor is pushed to 105 decibels, the law forbidding to exceed 120 decibels. The neighbors of the university residence Bachelard and those of the buildings of the alley Vauban do not really know what to expect ... According to "La Voix du Nord" on Monday 14.06.2010

problematic
How to protect yourself from noise?
Scientific questions
Identify four scientific questions that address this issue
For this you will need:
• observe the available equipment,
• formulate hypotheses and develop one or more experimental protocols,
• make one or more series of measurements,
• exploit the results, validate the hypotheses and make a conclusion,
• communicate to the other groups the results obtained.

Serviceable material: Smartphone application
Simple tone generator or Frequency generator.
Sound Level Meters, Materials…

Sequence 5- Jump without Parachute

Pedagogical intention

This sequence shows that the analysis of a sporting activity is possible using scientific knowledge and methods. On the other hand, they will approach the principle of the relativity of movement through a widespread sporting activity.

Skills worked

- Justify and set up a protocol
- To be critical
- Extract information on various media
- To lead a scientific approach
- Teamwork

Interdisciplinarity

- Mathematics
- Physics

Knowledges

Steps	Contents	Timing	Organization
1st part	Prerequisite and voting system	10 minutes	Whole class
2nd part	Propose an experimental protocol	15 minutes	Small groups
	Experimentation	30 minutes	Small groups
	Analyse des résultats	10 minutes	Small groups
	Analyze of the fall	15 minutes	Small groups
3rd part	Make a collective written record	10 minutes	Small groups

Description of the sequence

This session was tested with a group of 18 students in Scientific 1st grade (16 years old) in high school.

Groups of **2 students** are formed. The duration of the session is 1:30 in the experimental room.
The problem is common, and each group will perform the same experiments. A written summary will be produced collectively at the end of the session.

Objectives
All students and the teacher:

- will check the prerequisites by a **diagnostic evaluation**

Students, into small groups, will have to:

- **appropriate** the problem,
- carry out **experiments** and **analyze** the results,
- answer the problematic,

All students and the teacher:

- will summarize the main concepts encountered during the session.

Location in progress
This session is a reinvestment session. Before this session, students took a class session and an exercise session. Then follow an evaluation session

Jump Without a parachute

First Part: prerequisite

Duration: 10 minutes

Activity 1 – Testing prerequisite

Purpose: to identify the knowledge's of the students about relativity from a video.
Tool: Video of a jump without parachute with landing on a trampoline:
http://www.dailymail.co.uk/travel/travel_news/article-2850142/Incredible-video-reveals-moment-thrillseeker-freefalls-plane-WITHOUT-parachute .html
Use of voting boxes.
Working methods: Whole class and voting system
Guideline :
The class views the jump video and answers the following questions:

- Does this video seem possible to you?
- Why does the person fall?
- What is the movement of the person during the jump?
- How does his speed evolve during the jump?

See the questions at the end of the document.

Part 2: Analyzing the fall

Duration: 1h10 minutes

Activity 2 – Experimental protocol

Purpose: allow the students to propose a protocol allowing to validate their hypothesis formulated in the fourth question: "How does its speed evolve during the jump? "
Working methods: small groups then whole class
Tool : student document, course, experimental material
Guideline: in small groups, students must find an experience to validate the hypothesis from the third question. For that they have a camera, an image processing software, a ball, a black screen. Once the reflection is complete, they expose it to others in the whole class. The discussions will reveal the role of friction during the fall. To simulate the friction forces, the teacher explains that it is possible to drop objects in a water-glycerol mixture.

Activity 3 – Experimentation

Purpose: thinking about how to carry on the experiment, being able to explain it clearly.
Working methods: Small groups or individually
Tool : student document, course, experimental material
Guideline: the students record the ball's fall in the air for half of the groups, in a water-glycerol mixture for the other half.

Activity 4 – Analyzing the results

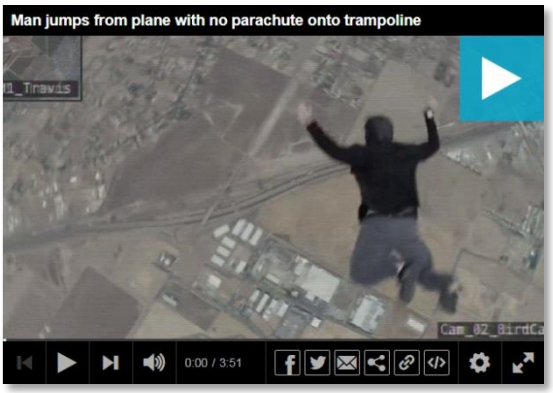
Purpose: to measure the evolution of the speed of the ball during the fall.
Working methods: in small groups
Guideline The results are pooled in order to measure the speeds and to note the increase of the speed with low friction and the uniformity of the speed during strong friction.

Activity 5 – Analyzing the fall

Purpose: to critize the images (critical mind), submit hypotheses explaining the video and checking them scientifically.
Working methods: Whole class
Guideline: Students take knowledge of additional documents made available and must conclude the feasibility of such a jump. These documents make it possible to calculate the theoretical braking height that the person should undergo so as not to be injured. It will be compared to the estimated height in the video.

STUDENT SHEET

➢ Jump without parachute



Watch the video and answer the questions:

- For which reason does the parachutist fall?
- What is the parachutist's movement during the jump?
- How does his speed change during the jump?

➢ Experimental protocole

Propose an experimental protocol in order to validate your hypotheses about the third question.

➢ Modeling experiment

Describe the experiment by making a diagram.

➢ Analysis of the fall to the ground

To analyze scientifically the possibility of such a fall, read the following documents and review your hypothesis above.

Document 1 : ***Extract of a website proposing first parachute jumps***

Feel like a tandem parachute fall? For an adrenaline rise and a pure magic instant? After being presented the material, the position, and the fall, you will get on the plane and fly to 3 000 meters. Then the plane door opens and big thrill. Enjoy this jump, and this pure moment of freedom and happiness.

After a few seconds with your trainer, you will reach 240 km per hour (200 km per hour if you're alone). You will never forget these moments.

Document 2 : ***Which braking process can a human being put up with ?***

A well trained human being can put up with a 12 g deceleration named a without damages (i.e $\boldsymbol{a = 12 \times g}$ with $\boldsymbol{g = 10\ m.s^{-2}}$). Beyond that figure health risks are to high. This deceleration is in relation with :

- the initial speed $\boldsymbol{v}$ just before deceleration,
- the braking distance $\boldsymbol{d_{braking}}$. This distance represents the distance necessary to stop i.e from top speed to full stop. The following relation enables us to calculate that distance :

$$\boldsymbol{d_{braking} = \frac{v^2}{2 \times a}}$$

with $\boldsymbol{v}$ $(\boldsymbol{m.s^{-1}})$, $\boldsymbol{d}$ $(\boldsymbol{m})$, $\boldsymbol{a}$ $(\boldsymbol{m.s^{-2}})$

Reminder: $\boldsymbol{v\left(m.s^{-1}\right) = \frac{v(km.h^{-1})}{3{,}6}}$

Do you think this video is a fake? Conclude.

Ressources 1st Part: Prerequisites

Why does the person fall?

- Because it is less heavy than the plane.
- Because the air pressure is lower in altitude,
- The mass of the Earth attracts her to her.

What is the movement of the person during the jump?

- At certain times the person is motionless compared to the cameraman,
- At certain times the person is moving in relation to the Earth,
- At certain times the person is moving in relation to the Earth.

How does his speed vary during the jump?

- It increases constantly until landing?
- It increases then becomes constant?
- It increases then decreases?