2019

Best practices to design training courses for science education at school

TABLE OF CONTENTS

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INTRODUCTION

Boosting Science Education at School is a 2-year Erasmus Plus Strategic Partnership project running from October 2017 to 2019, aiming at bridging the gap between schools and science.
The partnership is composed of the coordinator Associazione Euphoria (Italy), four scientific organizations – The science zone (Italy), Digital Idea (Greece), Science Centre AHHAA (Estonia), Ludor Engineering (Romania) – and four schools of different levels – Istituto Comprensivo "Maria Montessori" (Italy), Moysiko Gymnasio-geniko Lykeio (Greece), Tartu Tamme Gümnaasium (Estonia) and Scoala Gimnaziala Barnova (Romania).
The project aimed at developing an exchange of best practices between schools and organizations active in promoting science among schools, in order to create synergies between the educational and scientific world.
This exchange was thought to facilitate the introduction of more attractive practices in teaching science at school and to develop an exchange of methodologies between the associations, in order to figure out the best ways in which they can settle a stable collaboration with schools.
The project aimed at inspiring science teaching by encouraging communication between teachers, scientists, and associations involved in different ways in the European science education, and supporting teachers in modernizing their methodologies and activities in the classroom.
Consequently, the project also aimed at improving motivation, learning and pupils' attitudes in science education, resulting in an increased scientific literacy and recruitment to science-based careers, equipping young people with the skills to achieve their full potential, and ultimately convert better jobs into better lives.

THE PROJECT IDEA

The project idea grew up combining three main considerations:

1) the educational system as a whole is facing new challenges both at national and EU level. The impact of the economic crisis and the globalization contributed in making significant changes in the role played by schools which are expected to:
- facilitate the transition to the labour market providing students with new competences;
- support students to choose their future careers;
- be more attractive and foster excellence between students.

2) the crucial role of science in education: science brings to innovation and to research. Students should acquire skills in science subjects, in order to become young scientists capable of innovation in a competitive society rooted in knowledge. Fostering science at school will also enable students to decide whether they want to pursue an upper education in the subject.

3) the key role of science in the society: science literacy is also important to enable future citizens to participate effectively in democratic decision making and policy making that, in the near future, will increasingly involve science. Our students, for example, might be called to vote about issues such as use

of GMOs, human cloning, energy resources etc. As stated by OECD Secretary-general Angel Gurrìa, "from taking a painkiller to determining what is a "balanced" meal, from drinking pasteurised milk to deciding whether or not to buy a hybrid car, science is ubiquitous in our lives. And science is not just test tubes and the periodic table; it is the basis of nearly every tool we use – from a simple can opener to the most advanced space explorer. More important, science is not only the domain of scientists. In the context of massive information flows and rapid change, everyone now needs to be able to "think like a scientist": to be able to weigh evidence and come to a conclusion; to understand that scientific "truth" may change over time, as new discoveries are made, and as humans develop a greater understanding of natural forces and of technology's capacities and limitations."

Starting from this context, partners firmly believe that it is crucial to bridge the gap between schools and science: it is a fact that many schools do not include in their educational path experimental phases and inquiry-based methods which are useful to teach the subject and make it more attractive for students.

As a consequence, school staff needs to be trained in order to adopt inquiry-based and other proven methods for more effective science teaching. This could help teachers in better preparing their pupils, involving them in different scientific activities and put them in contact with the "real" science.

This is why we intend to provide teachers with practical supports and tools to develop more engaging scientific activities and… boosting science education at school!

NATIONAL CONTEXTS OF SCIENCE EDUCATION

Teaching science at school is different in every country. Differences range from numbers of hours dedicated to science to the methodologies applied - from a more theoretical to a more practical and hands-on approach, for example.

In the following tables we would like to show a comparison of the different educational systems of the 4 countries involved in the project, with a specific focus on the science field.

GENERAL INFORMATION:

Schools levels sorted by age of students			
Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	From 6/7 to 13 years	From 13/14 to 16 years	From 16 to 18/19 years
Italy	From 6 to 10 years	From 11 to 13 years	From 14 to 18 years
Greece	From 6 to 12 years	From 13 to 15 years	From 16 to 18 years
Romania	From 6/7 to 11 years	From 11 to 14 years	From 14 to 18 years

Number of days in the school year

Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	175	175	175
Italy	Minimum 200	Minimum 200	Minimum 200
Greece	175	175	175
Romania	168	168	154

Number of hours in the school day

Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	4-6	6-7	7
Italy	5-8	6-7	5-7
Greece	5-6	6-7	6-7
Romania	4-5	5-6	6-7

Study materials: free or not

Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	Free (*)	Free (*)	Free (*)
Italy	Free	Paid by families	Paid by families
Greece	Free	Free	Free
Romania	Free	Free	Free

(*) In Estonia, only workbooks are paid by families.

Headmaster's autonomy in the school management

Countries	All levels
Estonia	The Headmaster hires teachers and leads the school in every aspect, for example, he/she is responsible for the relations between the municipality (the state) and school. The Headmaster decides (with a board of teachers and parents) the general direction of the school (study branches and image).
Italy	The Headmaster is "responsible for the management of financial and instrumental resources and the results of the service. The Headmaster organizes school activities according to efficiency and effectiveness criteria and is the owner of trade union relations" (legislative decree n. 165/01, art.25). The Headmaster is a School Manager managing the financial resources, and must periodically report the budget to the Council of Institute, where all the members of the Educating Community are represented (teachers, parents, administrative staff, students). He/she signs each document issued by the school, for which he/she is responsible.
Greece	All positions of school headmasters are filled by formal qualifications and interview to Ministry of Education committee. Headmaster with a board of teachers follow the programme set by the ministry of education. Headmaster is at the top of the school community and he is an administrative and scientific pedagogical officer in this area.
Romania	All positions of school headmasters are filled by exams. The school headmaster is what we call a "line manager" or "middle manager": he/she directly coordinates processes, is in relationship with the students and teachers, parents and local autority.

Teachers' autonomy in organizing lectures

Countries	All levels
Estonia	Teachers need to follow the curriculum given by the State, but they are free to decide how they teach and grade as long as they fulfill the objectives of the curriculum.
Italy	Teachers' autonomy is given both as individuals "teachers are guaranteed freedom of teaching as to didactic autonomy and as their free cultural expression", and as Institutions "The autonomy of educational institutions is a guarantee of freedom of teaching and cultural pluralism and is embodied in the implementation of education and training aimed at the development of the human person, adapted to different contexts, to the demand of families and to the specific characteristics of the subjects involved". In this framework, teachers are invited to follow the National Curriculum Guidelines, drafted by the Ministry of Education for each school level.
Greece	Teachers each day apply the curriculum predetermined by the Ministry of Education. However the school counselors help the teachers to propose the way of teaching each subject.
Romania	There is a unique school curriculum, approved by the Ministry of Education for all disciplines, which applies at national level. Apart from this, each teacher can manifest his originality in designing and unfolding lessons. In the current system, to become a teacher, one has to follow a university course and to graduate from the Psycho-pedagogic Module that gives the right to teach. After graduating, the person has to take part in the competition where you he/she gets a job as a teacher. All teachers are continuously forming, taking part in exams in education and exams for grades.

SCIENTIFIC FIELD:

Approach to science: academic or practical?			
Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	Depends on the teacher. Mostly practical.	Depends on the teacher. Mix of academical and practical.	Depends on the teacher. Mostly academical.
Italy	Depends on the teacher. Mostly practical.	Depends on the teacher. Mix of academical and practical.	Depends on the teacher and the type of school
Greece	Mix of academical and practical.	Mix of academical and practical.	Mix depending on the subject.
Romania	Mix of academical and practical.	Academic	Academic

Number of STEM lessons per week

Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	23 Maths 10 Natural Sciences (*)	13 Maths 20 Natural Sciences	13 Maths 20 Natural Sciences
Italy	6-10 Maths, 2 Natural Sciences, 2 Geo	4 Maths, 2 Natural Sciences 1 Geo, 2 technology	3-7 Maths, 2 Natural Sciences, 1 Geo
Greece	5-6 Maths 3-4 Natural Sciences	4 Maths 6 Sciences	5-7 Maths 8-12 Sciences
Romania	4 Maths 1 Natural Sciences	4 Maths 6 Sciences	Depends on the school profile

(*) In Estonia, teachers have a maximum of hours/lessons to be given to students within the primary, lower secondary and upper secondary level. For example, the primary level lasts 6 years, and they have 10 lessons for 1-3 grades and 13 lessons for 4-6 grades. But the division of such lessons over the years (e.g. the actual number of the lessons per week) depends on the teachers' choice.

STEM subjects for each level (*)

Countries	Primary school	Lower Secondary school	Upper Secondary school
Estonia	Maths, natural sciences	Maths, natural sciences (*)	Maths, physics, chemistry, biology, geography
Italy	Maths, geometry, natural sciences and ICT (**)	Maths, geometry, biology, earth science, ICT	Maths, physics, biology, earth science, astronomic geo, chemistry, ICT
Greece	Maths, natural sciences	Maths, physics,chemistry, biology, ICT, geography	Maths, physics, chemistry, biology, ICT
Romania	Maths, natural sciences	Maths, physics, chemistry, biology	Maths, physics, chemistry, biology

(*) Please pay attention that this table must be read in relation with the one explaining the different ages for the levels in the different countries. It affects the diverse subjects for each level.

(**) In Estonia, natural sciences consist of biology and geography in grade 7 and separate chemistry and physics lessons in grade 8.

(***) In Italy, ICT includes coding.

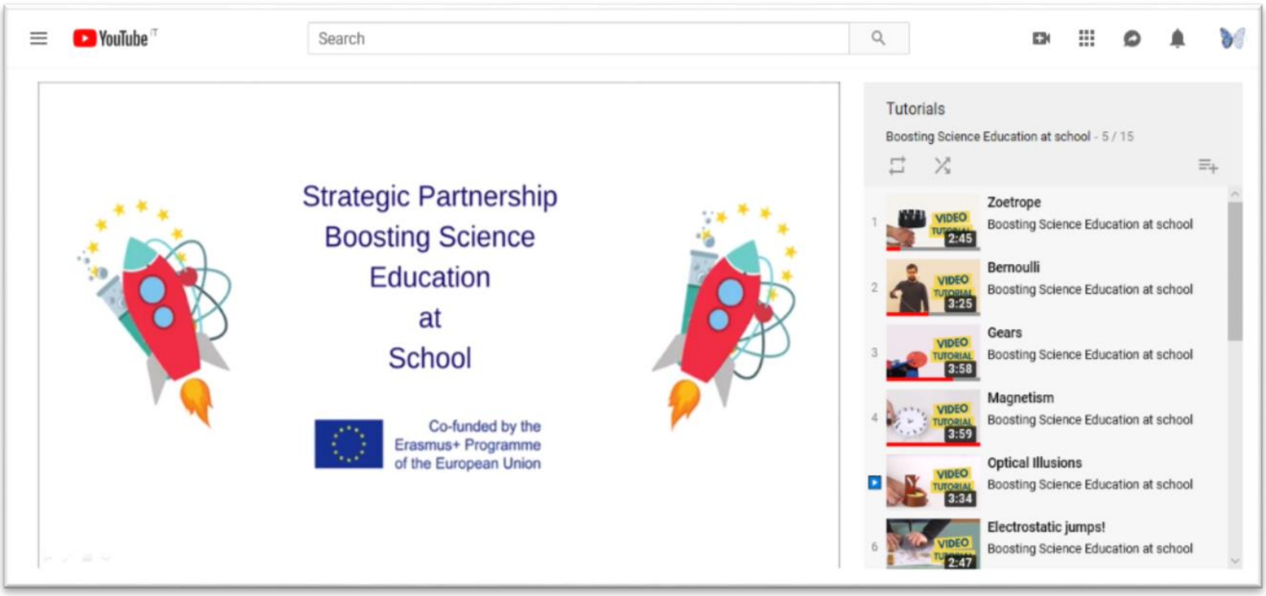
ACTIVITY SHEETS

Along our project, we organized 4 training activities during which each scientific partner showed its experience in organizing laboratories and activities to boost interest towards STEM subjects among students, and prepare teachers in dealing with them.

After, we have prepared 20 video tutorials thanks to which teachers can replicate such activities at school. The spoken language of the video tutorials is English, but they have been subtitles in Estonian, Italian, Greek and Romanian so they are useful also for teachers who do not speak English.

Each video tutorial is accompanied by a description of the experiments, the learning scenario and various tips to implement them. You will find all such information in the next activity sheets.

You can find all the video tutorials on our Youtube Channel: www.youtube.com/boostingscience



TOOLBOX: INQUIRY-BASED SCIENCE EDUCATION (IBSE)

Before using our video tutorials and the linked activity sheets, we would like to provide you with an extra-input.

Of course, you will be free to replicate the activities as you wish in your classroom, but we would like to suggest you a method which could stimulate even more the scientific approach within your students: the inquiry-based science education (IBSE) teaching of science through investigation.

It is a pedagogical method that puts the ideas, questions and observations of children at the center of the educational experience[1].

In doing so, both the scientific communicators (in general, the educators), both the children (the students) share the same responsibility in the learning process: here, the freedom to research how some phenomena occur – through experience and confrontation with one's own classmates - manifests itself in the responsibility for the construction of collective knowledge[2].

Together, educators and students build learning experiences by accepting mutual responsibility in the design and the evaluation of the various phases of learning and improving the individual, as well as in that of the whole class.

This peculiarity of the IBSE method implies a greater commitment during the educational experience, both on the part of the pupils and on the part of the communicators: pupils are required to participate actively in the definition of the investigation path, tutors need to re-learn with the kids every time.

In short, we could operationally condense the IBSE method in this way:

- We put the ideas and reasoning of the students to the focus of the discussion, developing with them both the initial path outlined by them and the investigation which follows;
- We create an environment for respectful discussion: we value the contribution of all;
- We intervene to get the students to give their contribution to the survey, ensuring that students have clear ideas and pay more attention to key concepts;
- We develop together questions that arise to interest them even more in the subject and ask them further questions;
- We give instructions or we take mini lessons when it is evident that the students need any new tools or concepts for progress.

[1] Ontario Ministry of Education. Inquiry-based learning. Student Achievement Division - Ontario

[2] Michel Rocard, Valérie Hemmo, Peter Csermely, Doris Jorde, Dieter Lenzen, and Harriet Wallberg-Henriksson. Science Education Now: a Renewed Pedagogy for the Future of Europe. European Commission

Inquiry-based learning consists of 5 phases[3]:

1. **Orientation**: building interest – finding connections with everyday life, daily news, watching videos.
2. **Conceptualization** (questioning and/or hypothesis generation): inquiry question consists of measureable inquired feature (e.g "how far will it fly?") and affecting factor ("The amount and type of fuel"), in hypothesis additionally there is also expected effect. With younger kids, instead of hypothesis it is better to start with making assumptions and later practice how to form assumptions into hypothesis.
3. **Investigation** (exploration or experimentation and data interpretation): Planning the experiment (what to measure, what should be constant, how to collect data), choosing suitable equipment (things can be shared to enhance additionally to teamwork also cooperation of teams), carrying out the experiment, analyzing data, correcting plan and trying again if needed (in case of engineering cycle).
4. **Conclusion**: Do the results support hypothesis or can the inquiry question be answered?
5. **Discussion** through all the phases (communication, reflection), also includes critical thinking.

Take a look at the experiments and their accompanying materials on pages 33-43 of this Best practice report, you will find experiments, worksheets and teacher guides following the IBSE method, designed by Science Centre AHHAA.
You can also have a look at some experiments carried out by The Science Zone according to the IBSE method: https://www.youtube.com/channel/UC70JvV5jWJIHGe40HBxUXTQ

And now... are you ready to start boosting science at school?

[3] Margus Pedaste, Mario Mäeots, Leo A. Siiman, Ton de Jong, Siswa A. N. van Riesen, Ellen T. Kamp, Constantinos C. Manoli, Zacharias C. Zacharia, Eleftheria Tsourlidaki. 2015. Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational Research Review, 14, 47-61.

Zoetrope (1/1)

Learning scenario

Divide the class into groups of 5-6 kids and give them the materials for the experiment. Work with them during the activity. First, take an A4 piece of paper and make templates for kids in order for them to know where to cut it. They have to form one long strip. This is the basic part of the zoetrope, it should look like a cylinder with small holes cut at the same distance from one another. Second, wrap the strip around the cylindrical container and tape it in place. If it is difficult for you to find a cylindrical container you can use CD disks. In this case, you have to change the template, this one needs to be applied to the disk. Third, using a craft knife or scissors, cut the cylinder to size and cut out the slots. Remove the template. Four, poke a hole in the middle of the bottom of the can and push a pencil partway through the hole. If you used a cd disk, it is already cut. Fifth, paint the outside of the cylinder black. Using black paint you can raise the effectiveness of the zoetrope. Six, cut out two strips with images, tape them together to form one long strip and place it inside the zoetrope. Place the marble ball on the hole that you poked. Finally, ask students to look through the slots at the images on the inside of the zoetrope as they spin it. It helps to hold the zoetrope under a bright light. Show kids the video tutorial and show them that you can do the zoetrope

Explanation

The zoetrope consists of a cylinder with slits cut vertically in the sides. On the inner surface of the cylinder is a band with images from a set of sequenced pictures. As the cylinder spins, the user looks through the slits at the pictures across. The scanning of the slits keeps the pictures from simply blurring together, and the user sees a rapid succession of images, producing the illusion of motion. The 3D zoetrope relies on the same principles but instead of flat 2D frames it uses 3D models and instead of the slits it uses a strobing LED light to illuminate each frame for a fraction of a second. The strobe and slits are necessary to freeze the frames, otherwise, you would just see a blur.

Duration: 45 minutes;

Objectives: construct a zoetrope and relate its operation to film and video;

Covered subjects: science; persistence of vision; engineering;

Topics: optical illusions, zoetrope;

Target group: students aged 6-12 years;

Materials: cardboard, black paint, cylindrical food container, printed draw with animation, adhesive tape, scissors, small marble ball;

Words for internet search: Zoetrope

Further information:
https://en.wikipedia.org/wiki/Zoetrope

Link to the video tutorial:
https://youtu.be/LV31pc65-70

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Bernoulli (1/2)

Learning scenario

Introduction - 10 minutes:
Speak with kids about flying. Ask them what they know about it and give them suggestions to guide their thoughts. You can ask them about birds and planes, about the wings of the birds and planes. Guide the discussion to the point where kids think about air. Ask again questions and give them indication to guide their thoughts. What is the role of the air in the process of flying? Does the air help? Can you say something about the characteristics of the air? Make some suggestions about pressure and density.
Divide the group - 10 minutes:
For a better understanding of the experiments, divide the class into groups of 5-6 kids and give them separate places into the classroom. Give them papers and markers and ask them to select the most important ideas from the discussion below. This way you will help kids to put in order the ideas and to think about what they do not understand. Kids will connect ideas about birds, planes, wings, air, and flight.
Experiments - 20 minutes:
Give kids the pieces of paper you cut. You can use recycled paper and cut it to 15x2 cm. Tell them that they have to take the piece of paper into their hand then hold it close to the mouth, and blow on top of the paper. Speak with them about what is happening. Let them discuss and give opinions. Prepare the second experiment. Give kids one hanger, 2 ballons, and thread. Explain to them what they have to do with all of this. You can see in the video tutorial how to use the materials. After setting up the experiment let kids blow between the two balloons and discuss. Ask kids what happened in the two experiments and what is strange about them. Speak about why the piece of paper goes up and why the two balloons stick together. Then prepare for the third experiment. Set the hair dryer to cool, switch it on, and point it at the ceiling. Put the ping-pong ball in the stream of air. Be careful to put the ball exactly on the stream of air. Hold the hairdryer steady and watch as the ping-pong ball floats in the stream of air.
Be careful to put the ball exactly on the stream of air. Hold the hairdryer steady and watch as the ping-pong ball floats in the stream of air. Move the hair dryer from left to right and watch how the ball moves as well, staying in the stream of air. Ask the

Duration: 45 minutes;

Objectives: gain awareness of the Bernoulli Principle;
explain that air pressure decreases as the speed of the air increases and that air pressure acts in all directions; apply the Bernoulli Principle;

Covered subjects: physics;

Topics: Bernoulli's Principle; lift (force);

Target group: students aged 6-10 years;

Materials: for everyone - paper 15x2 cm, 2 ballons, 1 hanger, thread; for demonstration - a hair dryer, balls of different sizes (some of them should be made of polystyrene);

Words for internet search: Bernoulli; Bernoulli Principle; lift force;

Further information:
http://bit.ly/2WPo6PD

http://bit.ly/2Zy0d0H

Link to the video tutorial: https://youtu.be/i3u9lPXN_BA

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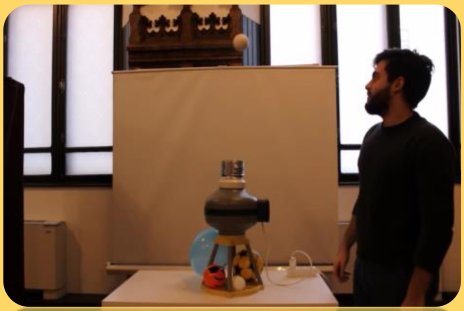
Bernoulli (2/2)

Learning scenario

Ask a student to place his hand above the ball. The ball should drop.
This represents turbulence above an airplane wing. Prepare the fourth experiment. For this, you will need a bigger ventilator. Try to float two or more balls in the same air stream. Ask kids what they think, how many can you float at once? How do they behave when there is more than one? Place balls of different sizes and watch how they behave on the stream of air.
Instructions and tips for the students:
Ask kids to get from their house hangers and thread, and give them the opportunity to find some more interesting balls.
After the experiment ask them to write conclusions and main ideas. This way you can make them think about what they saw and what they learned about.



Explanation

Bernoulli Principle states that as air moves around an object, it creates different pressures on that object. When the air moves faster it creates less pressure. When the air moves slower it creates more pressure. Why the piece of paper goes up? Because when you blow the air you are increasing the speed of it over the paper and the pressure above the paper decreases. The higher pressure below the paper pushes up and causes the paper to rise. Why the two balloons stick together? The fast-moving air that you blow between the balloons lowers the air pressure between them. Both balloons are moving closer to the area where there is less pressure. How can we explain the flight of different balls? There are two primary explanations for this demonstration. A.) There is a moving stream of air traveling around the ball resulting in an area of less pressure. The ball is prevented from falling out of the moving stream of air because it is pushed in by the higher pressured air adjacent to the moving stream of air. B.) The air travels around the ball and is moving at the greatest velocity at the top of the ball, resulting in an area of low pressure above the ball. The ball is drawn toward the area of low pressure. This area of low pressure can be disturbed by placing a hand above the ball.

Gears (1/2)

Learning scenario

Introduction:
The purpose of this lesson is to give kids something to think about, to make them curious to ask questions and to find answers. First, divide the class into groups of 5-6 kids. Use their help to organize the class and to put the tables into separate spaces for each group. Give them gears of different sizes and tell them to play with them. They will have three gears of different sizes: small, medium and big. Tell them to choose two of them and to start playing and observing. Students can change the gears after they observe them and if they need they can rotate the three gears at the same time. Once they rotate two gear they have to observe something. Ask them what they observe. Help kids find the right questions and the right answers. Ask them about the number of teeth, about the sense of rotation, about the speed. After finding their answers ask kids to write down the main ideas and to draw useful explanation.
Understanding gears:
Organise a game and ask kids to think about where they can use gears and for what. Ask them to write down the uses. After 5 minutes of speaking and analyzing ask kids to present their list and to explain why they thought this way. With this game, kids will try to remember if they saw gears in some mechanical devices and they will name them. You can speak about bicycles where gears work together to change the relationship between the driving mechanism and the moving parts. On a bicycle you change gears depending on terrain. Motion Another part of the lesson is to explain motion. We will explain three types of motion, circular motion, linear motion and oscillatory motion. Ask kids to think about each one of this moves and to say what they think about it. Ask them to give examples.
Give them materials to test each of this moves. They already have gears, give them a ruler for linear motion and a small pendulum for oscillatory motion.
Show kids the video tutorial and discuss what they learned. Speak about the way all of those three moves are connected in the mechanical device.
Feedback, experience: there are more ways in which you can do this lesson. You can make a mechanical device like the one presented in the video tutorial.

Duration: 30 minutes;

Objectives: Explain the role of gears in mechanical devices; explain how gears can be used to create motion;

Covered subjects: physics;

Topics: gears, motion;

Target group: students aged 6-10 years;

Materials: gears of different sizes;

Words for internet search: gears, motion;

Further information:
http://bit.ly/2x0696q

http://bit.ly/2FcO3lY

Link to the video tutorial:
https://youtu.be/TirFWNyr2bM

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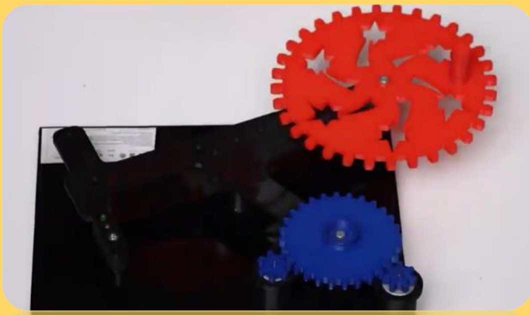
Gears (2/2)

Learning scenario

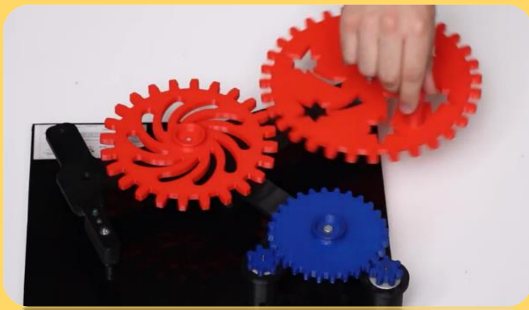
It is easy to make it if you use a 3D printer. If this is not a solution for you, you can make your own gears from cardboard. Choose a cardboard, one that is thick, or two pieces less thick that can be glued together, cut it in circles of different sizes and insert beads with pins on the edges.



Explanation

Gears are helpful in machines of all kinds, not just bicycles. They're a simple way to generate more speed or power or send the power of a machine off in another direction. Gears are simple machines. When we try to connect two gears of different sizes, we can:

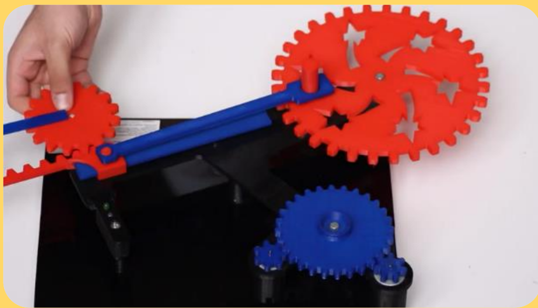
Change direction: When two gears mesh together, the second one always turns in the opposite direction. So if the first one turns clockwise, the second one must turn counterclockwise.



Increase force: If the second wheel in a pair of gears has more teeth than the first one it turns slower than the first one but with more force.

Increase speed: If you connect two gears together and the first one has more teeth than the second one, the second one has to turn round much faster to keep up. So this arrangement means the second wheel turns faster than the first one but with less force.

We can use gears to explain different types of motion. You can see this in the video tutorial, circular motion with the gear, linear motion, and oscillatory motion, with the hand. You can see that gears are used for transmitting power from one part of a machine to another.



Magnetism (1/1)

Learning scenario

Encourage students to discuss their experience with magnets, then let them know that they are about to perform a series of simple experiments that will show which of a group of objects will be attracted to a magnet.

Divide the class into groups and give each group the materials. Before the experiment, ask students to predict which materials will be attracted by the magnet and which will not. Ask kids to write down their prediction in two charts. Ask students to test each object or substance with the magnet. On their charts, they should record what was attracted by the magnet and what was not. Ask them if their predictions confirmed. Then give kids the compasses and ask if they know what are they used for. Ask them if they know something about the Earth and about its magnetic field. Explain that the north pole of a magnet points roughly toward Earth's north pole and vice-versa. That's because Earth itself contains magnetic materials and behaves like a gigantic magnet. Think about ancient people, for them, magnetism must have seemed like magic. We can see that if we hold two bar magnets so their north poles are almost touching, they'll push away from one another; If magnet's north pole is near the other magnet's south pole, the magnets will pull toward one another.

Explanation

A magnet has two ends called poles. One is called a north pole or north-seeking pole, while the other is called south pole or south-seeking pole. The north pole of one magnet attracts the south pole of another magnet, while the north pole of one magnet repels the other magnet's north pole. Magnets can attract other magnets or other magnetic materials through a magnetic field. The red pointer in a compass is a magnet and it's being attracted by Earth's own magnetism. Earth behaves like a giant bar magnet with one pole up in the Arctic (near the north pole) and another pole down in Antarctica (near the south pole). If the needle in your compass is pointing north, that means it's being pulled toward something near Earth's north pole. Since unlike poles attract, the thing your compass is being attracted to must be a magnetic south pole. What we call Earth's magnetic north pole is actually the south pole of the magnet inside Earth.

Duration: 45 minutes;

Objectives: determine which objects are magnetic and which are not; observe that magnets have two sides like the Earth;

Covered subjects: physics;

Topics: magnetism;

Target group: students aged 6-12 years;

Materials: 2 common magnets for every child, 10 strong magnets; compass for every group; different objects including some that will and some that won't be attracted by a magnet (e.g. aluminum foil, paper, keys, clips, beans); a computer with Internet.

Words for internet search: magnetism, magnet, north pole, south pole, compasses;

Further information:
http://bit.ly/2WLaV1S

Link to the video tutorial:
https://youtu.be/N7hWXaBXH7g

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Optical Illusion (1/1)

Learning scenario

This lesson can serve an important purpose in class and in life in general. The main objective is for kids to understand why optical illusions occur. We can say that we can't always trust our eyes.
Divide the class into groups of 5-6 kids and give them the printed papers with the illusions. You can choose whatever you want. We recommend 10 images with optical illusions.
This image is an example, it represents the Müller-Lyer illusion. It consists of two stylized arrows that appear to have different sizes. Ask kids to analyze each image, to explain it and to demonstrate why it is an illusion. After the first experiment, show kids the video tutorial and then talk with them about what they saw. Ask them to explain the illusions. Ask helpful questions and give the indication to guide their thoughts. Ask kids if they know why the optical illusions happen.

Explanation

Things can appear as more than one thing at different times depending on how you look at them. Things aren't what you think they are. Things can be more than one thing at the same time, and your mind and sight can be tricked by something rather simple in the end.
Ambiguous cylinder illusion - Based on whether you're looking at it in a mirror or in person, it's a shape that appears to simultaneously be two different shapes, a small plastic square or a circle. Each piece is the exact middle ground between a circle and a square. The tops of the sides are wave patterns. Two sides dip up, and two sides dip down. Combined, the sides "correct" the shape, depending on which way the shape is projected in a mirror.
Straight Pole Curved Hole Optical Illusion - You can see a rotating pole that somehow appears to fit through a curved hole. How does this work? The first thing to note is that the pole is not attached perpendicularly to the base but it's at an angle. Because the straight pole is at an angle, the base of the pole passes through the hole first. Then, each section of the rest of the pole slowly passes through, working upward until the whole thing fits.
Impossible object illusion - Why is it impossible? Because it is a two-dimensional object made to look three dimensional — depending on the angle you perceive it at. The impossible triangle presents itself as an object that seamlessly conjoins different sides of a triangle, but that depends on the angle you look at it.

Duration: 45 minutes;

Objectives: understand why optical illusions occur; explain different types of optical illusions;

Covered subjects: optics, physics;

Topics: perceptions;

Target group: students aged 6-12 years;

Materials: a computer and a video projector; printed pictures with optical illusions;

Words for internet search: Optical illusion, perception;

Further information:
http://bit.ly/2wZy0DG

http://bit.ly/2MSqPIl

http://bit.ly/2N2iUs2

Link to the video tutorial:
https://youtu.be/TEstaBDYh9U

QR code

Electrostatic jumps! (1/1)

Learning scenario

Put the sheet of paper on a flat surface (a table), then put the supports at the corners. Drop some sugar, salt and pepper on the paper and then put the plexiglass sheet above the supports. Rub the plexi with the woolen cloth and see what happens. Then repeat the experiment with lentils, paper, aluminium.

Divide the pupils in groups of 5. Let them try the basic experiment and then vary the experimental setting and observe what happens. For example, change the distance between plexi and the table, use a different cloth (material) to rub the plexi, change weight and dimensions of the objects and/or material of the support. Observe that attraction depends on distance, “intensity” of rubbing, materials you used (stronger for conductors). For a success in the experiment you have to use very light objects and spread them widely and evenly on the paper. Let the students do the experiment with your help and take notes of observations .

Explanation

Matter is generally neutral but it can be electrified by rubbing it, that is by trasferring charges by mechanical work. Plastic (plexi) is negatively charged when rubbed with wool (cloth), this induce a redistribution of charges in nearby objects, by polarization for insulators (paper, lentils, sugar, pepper,salt) and by induction for conductors (aluminium). The objects are attracted to the plexi due to the electrostatic force (opposite charges). Notice that you can see also repulsion between pieces of aluminium (they get the same charge by contact).

Duration: 45 minutes;

Objectives: exploring how static electricity works, the existence of different charges and the behaviour of different materials under electrostatic force.

Covered subjects: science, physics;

Topics: static electricity;

Target group: students aged 8-13 years;

Materials: for one group - white paper sheet (1 per group); 4 isolating supports (wooden, plastic, etc.); a bunch of light and small objects like sugar grains, salt, pepper, dried lentils, pieces of paper, pieces of aluminium foil; 1 woolen cloth; 1 sheet of plexiglass (20x20 cm);

Words for internet search: static electricity, Coulomb’s Law, charge, conductor, insulator, electrostatic force;

Link to the video tutorial: https://youtu.be/K74RoAvfhms

QR code

Discovering acid and bases by colours (1/1)

Learning scenario

Prepare the cabbage juice by boiling the red cabbage in a pot until it becomes violet, then filter it. Prepare five glasses and put them side by side. Fill each glass three-fourths with cabbage juice. Add bicarbonate to one glass, vinegar to another one, lemons and ammonia to another (using syringes, be careful ammonia is dangerous). Keep a glass of purple cabbage juice to show the colour of a neutral solution. Stir with a spoon and observe that the colour changes in different ways in each glass. You can also check with pH indicator stripes the acidity of substances that you add and see that the colour is the same of the cabbage with the substance. In the classroom, let the students choose the liquids to mix and ask them to write down in a table the transformations they observe. Let the students do the experiment with your guidance and take notes of observations.

Explanation

Substances are classified as either acid or a base. Acids have a low pH and bases have a high pH. We can tell if a substance is an acid or a base by means of an indicator. An indicator is typically a chemical that changes colour if it comes in contact with an acid or a base. Red cabbage contains a pigment called anthocyanin that changes colour when it is mixed with an acid (red) or with base (blue-green).

Duration: 45 minutes;

Objectives: to measure acidity and basicity by interaction of substances with a pH indicator;

Covered subjects: science, chemistry;

Topics: acid and bases; chemical reactions; enviromental properties, pH and neutralization;

Target group: students aged 12-14 years;

Materials: for 20 kids - spoons (3 per group of students); small glasses (5 per group of students); red cabbage juice (for 2 liters, boil half of a red cabbage in 3 liters of water for 30-45 mins); bicarbonate (half a glass – 200 g); vinegar (1 glass); 2 lemons (sliced); ammonia (half a glass); syringes without needle (1 per group of students) to provide kids with ammonia without them handling it directly; pH indicator stripes (5 per group of students);

Words for internet search: Red cabbage, PH, acidity, PH indicator, anthocyanin;

Link to the video tutorial: https://youtu.be/wdyDqNfqKm8

QR code

Leaf Life Lab (1/2)

Learning scenario

First, pour water into the transparent glass, then add half of a tea spoon of bicarbonate and a drop of soap and mix the solution. Cut 5 or more uniform leaf disks using the hole punch. Remove the plunger of the syringe and place the leaf disks into the syringe barrel. Replace the plunger and push it being careful not to crush the leaf disks. Fill the syringe with the bicarbonate solution from the glass. To press out the gas from the leaf disks, cover the syringe-opening with a thumb and draw back on the plunger to create a vacuum. Hold this vacuum for about 10 seconds while swirling the leaf disks to suspend them in the solution. Let off the vacuum. It may need a few repeats to remove all the gas from the leaf disks. You can see that the gas is removed when the leaves go to the bottom of the syringe. Finally, put the leaf disks back into the glass under a light source and wait until the leaves slowly go up and reach the surface. It may take a few minutes. In the classroom divide the pupils in groups of 5 and let them do the experiment and then vary the materials and notice what happens. For example, trying different light sources they can see a difference in the time it takes for the leaves to float. The students can notice that the best light source is sunlight while commercial LED does not work. This is because the wavelength of light produced by commercial LED is different than the one plants use. Once all the leaf disks have floated to the top, students can place the glass in a dark cupboard and see how long it takes for them to sink. Pupils can try leaves from different plants. They will notice that the plants that have the leaf surface smooth and not too thick, take less time to float than the others. Let the students do the experiment with your guidance and take notes of observations.

Explanation

Photosynthesis is a process used by plants to convert light energy into chemical energy stored in carbohydrate molecules. To do photosynthesis, plants need carbon dioxide, water and light. Using photosynthesis, sugar molecules and oxygen are produced.

Duration: 20 minutes;

Objectives: to investigate the role of light on oxygen production in photosynthesis;

Covered subjects: biology;

Topics: plant physiology, photosynthesis;

Target group: students aged 10-13 years;

Materials: for one group - sunlight or strong artificial light (not commercial LED); tea spoon; transparent glass; syringe (no needle!!); hole punch; bicarbonate (baking soda, half of a tea spoon); dish soap (1-2 drops); spinach leaves; water (a glass);

Words for internet search: Photosynthesis, oxygen production, leaf disk, plant;

Link to the video tutorial: https://youtu.be/wS3TFERvU9E

QR code

Leaf Life Lab (2/2)

Explanation

The bicarbonate added to the water serves as a source of carbon dioxide while soap decreases the surface tension of water so the leaf disks could easily drop to the bottom of the glass.

Actually, normally leaf disks float because they contain gas inside them. When the air spaces are replaced by water, the overall density of the leaf disk increases and the disk sinks. When you see the leaf disks slowly going up, it is due to the oxygen produced. As density of gas is lower than water density, the leaf rises up, finally reaching the surface.

Let's swing (1/2)

Learning scenario

Single Pendulum

This experiment involves many different steps and activities, so it is a good choice to make the students split tasks among themselves.

Let the students build a pendulum using a rigid frame (a chair on a desk), the fishing wire and nuts and decide the number of complete oscillations they want to observe. Using the stopwatch, make them observe and write down the time needed for the pendulum to perform the decided number oscillations.

Make the students repeat the experiment as many times as they want (around 10x), then help them decide a single number to represent all the results obtained: you could suggest them to take their 'average'.

Repeat the above procedure by changing some details:

1) number of nuts tied to the bottom end of the wire;
2) starting position of the nut;
3) material composing the wire;
4) length of the wire.

It's very important to change one detail at a time, while keeping the other details the same.

Make the students compare the results coming from the different experiments and draw some conclusion. Ask them the question: does the time needed to complete the number of oscillation you decided, change bynchanging the details of the experiment?

Coupled Pendulum

For this experiment, it is better to use a softer thread than the fishing wire: try with a thin rope. Tie two end of a rope to two rigid structures, so that it is horizonal and well stretched (this is very important). Build two pendula by fixing their upper end to the horizontal rope. Make sure that both pendulas are steady. Displace the nut of one of the two pendulas and let it go. Observe what happens.

Duration: 45 minutes;

Objectives: to learn the concepts of periodicity, frequency and resonance; to develop qualitative (description) and quantitative (measurement) scientific methodology approaches;

Covered subjects: science, mechanics (physics);

Topics: oscillations and resonance in a pendulum; periodic motion and transfer of energy;

Target group: students aged 10-12 years;

Materials: for one group/10 kids- metal nuts (x 12); fishing wire (10 m); other kinds of thread (10 m each; ropes, ribbons, etc); some kind of rigid support (1-1.5 m tall); tape (a few pieces, if need to hold some structures); stopwatch for measuring time (accuracy of tenths of seconds is enough; e.g., those from smartphone apps);
paper, pens and colors to record results, make plots, tables and sketch the experimental setup;

Words for internet search: Pendulum (motion), oscillation, coupled pendulum, air friction;

Link to the video tutorial:
https://youtu.be/5aPqS5wohek

QR code

Let’s swing (2/2)

Explanation

Single pendulum – First, you will notice that the pendulum makes always the same movement: back and forth, back and forth, …and it always take the same time do it! This property is called ‘periodicity’: a movement is ‘periodic’ when it repeats itself over and over, taking always the same time. In particular, the time needed to perform one of these equal movements (one oscillation, in the case of a pendulum) is called ‘period’.

Hopefully, you will then notice that the time needed to perform a fixed number of oscillations will not depend on the initial displacement of the nut, the number of nuts tied to the bottom end of the wire nor the material composing it. Instead, it will depend on the length of the wire! In particular, the longer it is, the longer it takes to complete a single (or a certain number of) oscillation.

Coupled pendulum – Once the first pendulum starts moving, you will notice that after a little time, the amplitude of its movement will start reducing until it almost stops, while the other pendulum (which was initially still) will actually start moving more and more. Waiting some more time, the second pendulum will reduce its movement, while the first one will start moving again, and so on. What is happening?

Everything which moves has some energy. This energy can be transmitted to other objects to make them move too: the only thing needed for this to happen, is a mean to transfer this energy. Pendula are continuously transferring energy to one another through the horizontal wire which connects their upper ends: if you notice, while they oscillate, they also move like thye are rolling on themselves. So, once one pendulum starts transferring energy to the other, it will start moving less, because it is away its energy. The other one, on the contrary, will receive energy, and use it to start moving.

Rainbow soup (1/1)

Learning scenario

Take a smooth, tight and tall glass. Put in the glasses 7 ml of each liquid in the following order: syrup, milk, dish soap, water with food colouring, sunflower oil, denatured alcohol. Use pipettes to help yourself to pour liquids. Drop very gently small objects into the glass and observe.
In the classroom, divide the pupils in groups of 5. Let students choose the order of the liquids to be poured into the densimetric column and try to identify the characteristics of liquids that are denser than those that are less dense. To better observe the different liquid layers, it is important to pour the different liquids very slowly. Do not immediately give pipettes to the students, let them choose different tools with which to gently pour the liquids. Let the students do the experiment with your guidance and take notes of observations.

Explanation

The density of a material is the number of particles of that material in a precise volume. Let us consider a cubic centimeter of material A and one of material B. If in the first there are 50 particles (material A) and in the second there are 100 particles (material B) then we will say that material B is denser than material A.

But very often these particles are too small to count. So it can be useful to understand if a material is more or less dense than another. In the case of liquid materials, we can use the densimetric column to evaluate which one is more dense than the other. We can simply pour them in a glass, on top of each other as shown in the experiment: water is denser than oil and alcohol but is less dense than milk and syrup etc.

We can also estimate the density of small objects immersed in the densimetric column by comparison: for example a sunflower seed is less dense than the alcohol while a plastic pen cap is less dense than dish soap, but more dense than oil and water. Be careful though: very often the concept of density is exchanged with the concept of weight! The weight depends on the force of gravity and for example it changes if we go to the moon. Density, instead, is a specific feature of a material and it does not depend on how much material we use or where we put it.

Duration: 40 minutes;

Objectives: to make a comparison of densities among solid and liquid with a density column;

Covered subjects: science, physics;

Topics: density, property of matter;

Target group: students aged 8-12 years;

Materials: 1 transparent glass; 2 pipettes; 7 ml of denatured alcohol (90%); 7 ml of fresh milk; 7 ml of dish soap; 7 ml of syrup (for example mint); 7 ml of sunflower oil; 7 ml of water; food colouring; 2 rubbers; 2 lentils; 2 grains of rice; different small items available;

Words for internet search: density, densimetric column, mass VS density, properties of materials;

Link to the video tutorial: https://youtu.be/fpa9ZuaUnV4

QR code

Coke drinks & Mentos (1/3)

Learning scenario

The team's task is to determine what to add to coke to achieve as high eruption of foam as possible.

Before taking the experiment outside, you can conduct preliminary tests indoors using 0.1–0.2 liter of coke in smaller containers (there will be no eruption if you use a glass).

If you plan to pour the test substances directly into a cola bottle, it is worth conducting the experiment outdoors. Place the bottle on a flat and firm surface so it would not fall over. Use wooden blocks or rocks for support. It is recommended to use personal protective equipment (goggles and coats).

The quicker you can get the selected substance into the bottle, the more powerful the eruption will be. You can pour in candy or tablets using a sheet of paper rolled into a funnel. You can also put them in another container with a narrower opening and use it to quickly pour them in the coke bottle.

In addition to the aforementioned test equipment, you can also use your own creativity and knowledge to test various substances.

Explanation

When you open a soft drink bottle, you can hear its unique hissing sound and see bubbles of carbon dioxide rising to the surface of the drink. The bubbles were not visible when the bottle was still unopened. Carbon dioxide has been dissolved in the drink under great pressure—the greater the pressure the more gas dissolves.

Uncapping the bottle relieves the pressure inside it. At lower pressure, the liquid can no longer 'fit' as much carbon dioxide as before—the solution becomes supersaturated. A supersaturated solution is a solution that contains more dissolved substance than you can actually dissolve in it. Consequently, the excess dissolved substance attempts to escape as gas or by sedimentation.

Duration: 45 minutes;

Objectives: to determine what to add to coke to achieve as high eruption of foam as possible

Covered subjects: chemistry, physics

Topics: gas solubility; pressure; supersaturated solution; surface tension; states of matter; chemical reaction and its characteristics; formation of raindrops, snowflakes and bubbles;

Target group: students aged 12-18 years;

Materials: Diet coke (at least 0.5 l; the final experiment requires at least one additional bottle - larger ones produce better results) - keep it in the fridge before use; mentos scotch mints, both peppermint and other flavours (1 roll); smooth-surfaced hard candy, e.g. Mynthon; activated charcoal tablets; dishwashing liquid (or some other cleaning agent); other substances of interest (e.g. table sugar); an outside area and rocks for securing the bottle; paper, a funnel or a narrow container for pouring candy in the bottle; personal protective equipment for each team member: a plastic raincoat, safety goggles, rubber gloves where necessary, glasses, containers or flasks;

Coke drinks & Mentos (2/3)

Explanation

Just like raindrops or snowflakes need a dust particle on which to grow in air that is supersaturated with water vapour, bubbles need a base to form on in a soft drink. In a soft drink, the sides of the bottle act like that base. Bubbles also form on objects or fingers placed in the drink. Just stick an object or a finger in the drink. Since bubbles have a smaller density than the solution, they rise up.

Bottle walls are smooth and thus not a good place for bubbles to form (even though some bubbles do appear there, especially in the upper part of the bottle). Mentos mints, however, have a porous surface, which promotes bubble formation.

Activated charcoal tablets also have a large surface and are thus a good place for bubbles to form on. At the same time, they are light and do not sink to the bottom of the container like Mentos mints. Mynthon pastilles (or other hard candy) are heavier than coke and sink to the bottom, but they have a rather smooth surface, which is not conducive to bubble formation.

Reduced surface tension caused by the waxes in Mentos and gum arabic (*) are also thought to be the reason for bubble formation. For this, they would have to dissolve in the drink. Bubbles mainly form because of the surface of the candy.

Surface tension is a phenomenon that is expressed in the contraction of the surface layer of a fluid (like an elastic membrane). Surface tension characterises the forces between the molecules of a liquid. The smaller the surface tension, the easier it is for the bubbles to form. Greater surface tension keeps bubbles small and promotes foaming.

Surface tension is reduced by aspartame found in diet coke. This is why we recommend you use it. This also makes cleaning easier, as it does not contain sticky sugar. Sugar and several other substances found in soft drinks increase the surface tension of the drink.

Why does adding Mentos (or another substance with a large surface) to a glass of coke produce a more modest eruption than when the drink is in a bottle?

Words for internet search: Coca-Cola + Mentos, soda geyser, nucleation, gas solubility, carbon dioxide, carbonated soft drinks, porous material, surface tension, tears of wine;

Further information:

Link to the AHHAA worksheet:
http://bit.ly/2RlsxAh

Link to the teacher guide:
http://bit.ly/2Xgj1UB

Link to the video tutorial:
https://youtu.be/3VM-Dy3x5FM

QR code

Coke drinks & Mentos (3/3)

Explanation

Glasses and bottles have different-sized openings. The released carbon dioxide reaches the air quicker in a glass than a bottle, because the latter has a smaller mouth. A bottle includes more bubbles per surface unit and it is more difficult for them to escape the bottle. The liquid starts to foam. Foam takes more space than liquid, because the gas in the foam has a smaller density than the liquid. The more bubbles are formed, the quicker the pressure rises. The quicker the pressure rises, the higher the eruption will be.

Was the eruption caused by a chemical reaction?

The foam is mainly caused by the release of dissolved carbon dioxide in gaseous state. Initially, it may look like a chemical reaction. Chemical reactions are characterised by:

- release of gas (in our experiment)
- occurrence, disappearance or change of colour
- occurrence or disappearance of an odour
- sedimentation,
- emission of light/sparks
- a temperature change.

Of the above, our experiment involves the “release of gas”.

Even though dissolution of carbon dioxide in water results in unstable carbonic acid (H2CO3) which breaks apart into carbon dioxide and water, most of the carbon dioxide in the solution still appears as carbon dioxide. Thus, most of the carbon dioxide released as a gas has been there in the solution since the very beginning and its release does not involve a chemical reaction.

* Gum arabic is E414 food additive that is collected from Gum arabic tree (Acacia senegal) and used as a thickening agent and stabiliser in chewing gums and jellies.

Water Purification (1/2)

Learning scenario

The group's task is to purify the water given to them. Even though the water that is to be purified is very dirty, this experiment focuses on methods suitable for purifying drinking water. These methods do not guarantee perfectly clean water, but in the case of dirtier water, you can better observe the method's effect.

Prepare or have each group prepare their own contaminated water. To this end, mix 0.5 l of water with ~0.5 tsp of pollen or tea, ~0.5 tsp of table vinegar, oil and, to achieve a particularly unpleasant result, garlic powder.

Pollen or tea act as substitutes for plant remains and vinegar for a chemical pollutant.

You can ask students to draw their water purification ideas on paper or blackboard. For instance, you can let them draw some ideas on the blackboard and divide themselves into groups so that each student goes near the author whose idea they liked the best or considered most interesting. If one idea is supported by a lot of students, you can divide them into several study groups that test the same idea simultaneously.

In order to purify water, it is worth letting it settle at first—this way part of the material sinks to the bottom. In order to remove oil, you can (should you wish) build a device using a funnel and a tube. If you pour water in the funnel while the hose is closed off, the oil rises to the surface. Then you can let the water out of the hose and close it at the right moment so that the oil remains in the hose.

You can make a water filter out of the neck of a plastic bottle or a paper cup with needle or thumbtack holes at the bottom. The bottom can be lined with gauze, cotton or filter paper and the filter filled with different-sized gravel, sand, cotton or activated charcoal. In the case of some filters, it is worth filtering the water several times and replacing the filter.

Explanation

The oldest method of water purification is boiling (water seasoned with garlic powder emits a lot of smell when boiled). This neutralises microorganisms and several toxic substances. However, boiling does not destroy algaecides.

Duration: 45-60 minutes;

Objectives: to purify the water given to them

Covered subjects: environment

Topics: water; water purification; filtration; water as a substance; water contamination; water use

Target group: students aged 12-18 years;

Materials: 1 plastic bottle; 4 clear containers or glasses; 4 paper cups; 2 sheets of activated charcoal (BBQ charcoal or activated charcoal tablets); scissors; a needle/thumbtacks; gravel; stone rubble; sand; gauze, cotton, filter paper and/or coffee filters; a funnel and a suitable hose (optional); water purification tablets, if possible (available in camping gear stores);
For contaminated water: oil, pollen/a teabag, table vinegar, garlic powder;

Words for internet search: water, water crisis, water filtering, water filter, activated charcoal, lifestraw

Further information:
Link to the AHHAA worksheet:
http://bit.ly/2RlsxAh

Water Purification (2/2)

Explanation – continues from previous section

Bacterial spores will also remain intact, which is why the effect of boiling is temporary.

It is also not suitable for small quantities of water (water evaporates) and requires an energy source (fire or electricity).

Boiling does not remove solid particles from the water. This is where filters come in. The finer the filter pores, the cleaner the water we get. A filter that has pores with a diameter of 0.2 micrometres (0.0002 mm) can remove bacteria, while 0.02 micrometre openings are able to mechanically remove most viruses. Sand filters are considered to be efficient - they consist of a thick layer of sand and work slowly. Some filters use pressure to speed up the process. Natural water also goes through a so-called sand filter before entering a spring if the surface layer contains sandstone.

Filtration does not remove odour and taste. These can be removed with activated charcoal, ozone, chlorine, silver or iodine. This experiment uses charcoal, but you can also try water purification tablets sold in pharmacies. You can see bubbles when you add charcoal. The unique smell should grow fainter, but does not disappear completely.

The most reasonable way to purify water is to combine these three methods, starting with sedimentation and removing the oil and then moving on to filtration and activated charcoal tablets. Charcoal can also be added to other filters.

In order to check the cleanliness of water you can also measure its conductivity in addition to visual observation and smelling. The higher the conductivity, the more ions, i.e. dissolved substances there are in the solution. Dissolved substances may not always be harmful to us - mineral water contains many ions, too.

You cannot completely purify the water used in this experiment with simple means. Even though the water does not include any harmful substances, tasting it is not recommended, because sand and gravel are probably dirty.

Link to the teacher guide:
http://bit.ly/2Xgj1UB

Link to the video tutorial:
https://youtu.be/ch-sakYrEUA

QR code

Hidden Iron (1/3)

Learning scenario

The task is to determine the foods and food additives from which you can extract iron using a magnet. Before buying the materials, you can ask students which foods and ingredients they want to test.

For instance, iron can be detected in Kellogg's corn flakes (the ingredients include iron) and particularly in Ferretab iron capsules (the capsules can be moved with a magnet), but also Retafer iron tablets. However, we could not see iron in R.A.U.D tablets containing iron (II) gluconate.

Iron is sometimes difficult to detect when the mixture is too thick. In addition to crushing the cereal and studying the mixture of water and crushed cereal, you can also separate larger chunks with a sieve in order to extract iron. You can also see iron dust if you soak cereal in water, pour the water through a sieve and then use a magnet to detect iron in it. It is worth remembering that the iron hidden in small pieces of cereal is light-coloured like the cereal itself.

When looking for iron dust, it is worth pulling the magnet towards one spot in order to gather the iron dust together. If you use a resealable plastic bag, remember that the particles that seem to be moved by the magnet may float in the bag due to the movement of the liquid.

You can try to remove the iron from the liquid and study it under a microscope or a magnifying glass.

Explanation

Iron can be extracted from some breakfast cereals using a strong magnet. Cereals contain some iron compound.

In this experiment, it is recommended to use as strong magnet as possible in order to collect iron dust and make it visible, mainly because the iron particles are very small. Iron dust can be gathered using a permanent magnet - a material that is always surrounded by a magnetic field.

Magnetic fields are invisible and not directly perceptible, but they are characterised by their ability to attract or repel other magnetic materials. Iron is a ferromagnetic material - it can become magnetised by an external magnetic field. Other ferromagnetic materials include cobalt, nickel and several rare metals.

Duration: 45 minutes;

Objectives: to see food and food additives from which you can extract iron using a magnet;

Covered subjects: chemistry, physics, human body;

Topics: magnetic materials in everyday life; food preservatives; metals necessary for human body; chemical elements as ions and in pure form; ferromagnetism;

Target group: students aged 12-18 years;

Materials: different types of breakfast cereal; breakfast cereal containing iron (e.g. Kellogg's); black olives; food additives containing iron (e.g. those that contain iron (II) fumarate (Ferretab) or iron (II) sulphate (Retafer)); additionally: a petri dish, a transparent container and/or a resealable plastic bag; a tablespoon; a sieve; (Hot) water; a coffee grinder, blender or a mortar and a pestle for crushing cereal; a very strong magnet
(e.g. a neodymium magnet); optional: a microscope or a magnifying glass;

Words for internet search: iron (in cereals), monster magnet meets blood, ferromagnetism, haemoglobin and ferritin, anaemia, leghaemoglobin, heme;

Hidden Iron (2/3)

Explanation

The strongest permanent magnets ($Nd_2Fe_{14}B$) are made of neodymium (a rare metal), iron and boron.

Iron cannot be extracted from certain foods or food additives. One of the reasons is that they may not even contain iron. Another reason could be that these foods or food additives contain iron in a form that does not react to a magnet (the electron shells of atoms are full).

Iron can be obtained from food as heme-iron or non-heme iron. Heme is a protein complex linked to iron. Heme can be found in blood in haemoglobin, but also in muscles in myoglobin. Heme can also be found in the root nodules of leguminous plants (leghaemoglobin).

Heme iron is absorbed more quickly than non-heme iron. Vitamin C and folic acid increase iron absorption. However, it must be considered that the free iron ions that occur during rapid release of iron may damage the digestive system.

Iron absorption is inhibited by coffee, alcohol, eggs (as much as 28%), casein (milk protein) and calcium, phytates (found in spinach and beans, for example) and oxalic acid (found in spinach and rhubarb, for example). It is not recommended to consume these foods together with iron-rich foods; you should wait at least an hour before and after the meal before consuming them. However, heating foods that contain phytates and oxalic acid improves the absorption of iron.

Even though iron plays an important part in the body, you must ensure that iron is not available for pathogens. Bacterial diseases or intestinal parasites reduce the availability of iron in the body. In such a situation, iron additives may do more harm than good.

Iron deficiency (anaemia) is the least common in men and menopausal women and common among women in childbearing age and expecting mothers.

Further information:

Link to the AHHAA worksheet:
http://bit.ly/31BA173

Link to the teacher guide:
http://bit.ly/2wZjgVe

Link to the video tutorial:
https://youtu.be/tCbph77GECE

QR code

Hidden Iron (3/3)

Explanation

Haemoglobin indicator provides information about the iron content in the body while iron stores are indicated by the ferritin content.

• A person weighing 70 kg contains 3–4 grams of iron. (To compare: 5-cent euro coin weighs 3.92 grams).

• Is it dangerous to be near large magnets, e.g. in a CT scanner?

The iron in our body is bound in a haemoglobin protein complex. This iron does not magnetise when bound to oxygen, only when it is free of oxygen. However, its effect is too negligible for CT scans to be harmful. (Search 'monster magnet meets blood'.)

LED Torch (1/3)

Learning scenario

The task is to build a torch with a switch. Consequently, participants need to build a circuit consisting of a light bulb, a power source and a switch. They also need to find a suitable battery for a LED.

Make sure that voltages are the same. If you choose a power source with too high voltage, the lightbulb may burn out. You need to consider the LED's specificities and connect it to the circuit properly.

If the bulb does not switch on, replace the terminals - the longer is usually the "+" terminal and the shorter the "–" terminal.

You can also use several batteries with a lower voltage than a LED's working voltage. Then you can discuss whether to connect the batteries in serial or parallel (in the first case, the voltages are summed up and, in the latter, the current intensities). For a more precise voltage regulation, you can use resistors and the parts of the circuit can be connected using a soldering iron.

One easy way to build a switch is to line a button cell with insulating tape. All that is left to do then is to design a casing for the torch. You can build a reflector in order to reflect light in the correct direction. This can be done with aluminium foil, for example.

Explanation

The first incandescent light bulb is said to have been invented by Thomas Alva Edison in 1879. There were more than ten of those who invented light bulbs similar to that of Edison before him. Two of them, Henry Woodward and Matthew Evans, sold their patents to Edison.

The light in the bulb is created by a filament heated using electric current. Incandescent light bulbs are not very efficient, since they only convert 5–10% of the energy they use into visible light. The rest of it is converted into heat.

Duration: 45 minutes;

Objectives: to build a torch with a switch;

Covered subjects: physics;

Topics: light sources and different lightbulbs, their efficiency; semiconductors; current intensity; electrical voltage; battery capacity;

Target group: students aged 12-18 years;

Materials: scissors; cardboard, paper, plastic cups, etc. (for building a casing); clothespins, paperclips, strips of metal, etc. (for making a switch); glue; tape; button cells (different types so that the student can use a suitable one); a LED (light-emitting diode) - with different intensities, if possible; aluminium foil for directing light (for making a reflector); optional: cable/wire, a soldering iron and solder, resistors and a switch;

Words for internet search: Homemade flashlight, reflector focus, satellite television

Further information:

Link to the AHHAA worksheet: http://bit.ly/2XY9oHq

LED Torch (2/3)

Explanation

The next widely used light source, the compact fluorescent lamp (energy-saving light), was invented in 1985. The section between the socket and the light-emitting tube features an electronic ballast for switching on the bulb, limiting the current and reducing reactive power consumption. It is a fluorescent light bulb. The closed tube, which is generally kept under low pressure, contains mercury and a noble gas, usually argon. Additionally, the walls of the glass tube feature fluorescent coating (e.g. phosphor), which is why the glass looks white. The operating principle is based on mercury gas solution, in which case the energy is mainly converted into UV radiation. The fluorescent layer on the inner surface of the bulb converts UV radiation into light spectrum close to daylight. The remaining UV radiation is absorbed in the glass tubing and is released as heat, causing the bulb to warm up. Thus, the better the luminophore, the less energy is left over and the more efficient the bulb is.

A compact fluorescent light bulb consumes considerably less power than an incandescent light bulb with the same light intensity and lasts up to 15 times longer.

The first usable LED was developed in 1962 by Nick Holonyak Jr, who is considered the father of the light-emitting diode. Back then, LEDs only came in red and were rather dim, which is why they were only used as indicator lamps.

LED technology is based on semiconductors (materials that do not conduct electricity under normal conditions, but can do so in certain conditions). A LED includes two different semiconductors in physical contact. If we apply positive voltage on the p-type semiconductor and negative voltage on the n-type semiconductor (connect them to a battery), the holes and free electrons begin to move (which is why a LED has to be correctly connected to a battery in order to work). Due to similar charges repelling each other, the holes and electrons move to the connecting surface between semiconductors. In this so-called transitional area, energy is released as a result of electrons and holes meeting and emitted as light. Each LED emits one specific wavelength (colour). Using different semiconductors allows you to achieve different coloured light.

Link to the teacher guide:
http://bit.ly/2wYi8RL

Link to the video tutorial:
https://youtu.be/_42nNBDH0Cw

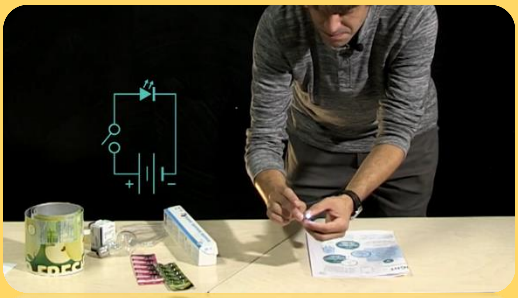
QR video

LED Torch (3/3)

Explanation

Compared to incandescent light bulbs, LEDs are very energy-efficient, consuming nearly 20 times less power.

Torches are equipped with reflectors - curved mirrors made from reflecting material (foil) - in order to direct as much LED light as possible at a certain point. In order to ensure that the (spot) light source emits as much light as possible to illuminate a certain area, the bulb must be in the focus of the curved mirror (reflector), which is shaped like a paraboloid. A focus is a point where the parallel rays of the optical system (a curved mirror or lens) intersect after refracting or reflecting.



Hidden Objects (1/2)

Learning scenario

The task is to hide a glass object inside a liquid, i.e. to find a liquid the refractive index of which equals to that of glass. You can determine the suitable liquid via experiments (suitable for smaller children), but you can also pretend that liquids have to be ordered in and there is no money for them all - therefore it is reasonable to do some research to determine the correct product.

Since different types of glass have slightly different refractive indices, it is worth calculating the refractive index of your glass yourself. In order to determine the refractive index, you need to measure the angle of incidence and the angle of refraction.

In order to make angle measurement more convenient we recommend that you:

• draw a straight line on paper using the side of a piece of glass and then a perpendicular line (normal) and direct the laser to the intersection of the lines;

• choose the ray's angle of incidence from a range of 30–60 degrees (light does not change the direction when falling perpendicularly on the boundary of two environments and goes straight through it);

• mark the exit point of the laser ray, the starting point of the ray entering the piece of glass and the exit point of the ray on paper - these can later be used to draw straight lines in order to measure the angle of the incident and refracted rays.

Once you have the refractive index, you can easily use this to find a liquid that has as similar refractive index as possible using the table on the first page of the activity sheet.

Duration: 2x45 minutes;

Objectives: to hide a glass object inside a liquid, i.e. to find a liquid that's refractive index equals to that of glass;

Covered subjects: physics;

Topics: light; light refraction; angle of refraction; angle of incidence; refractive index;

Target group: students aged 12-18 years;

Materials: a clear drinking glass; a rectangular glass object; water (n=1.33); spirit (n=1.36); 25% sugar solution (n=1.37, you can mix it yourself: 1 part of sugar and 3 parts of water); glycerine (n=1.47) or cooking oil (n = 1.44...1.47); a laser; a pencil; a ruler; a protractor; A4 paper; a calculator;

Words for internet search: angle of refraction, angle of incidence, optical environment, optical density, refractive index, short-sightedness (myopia), far-sightedness (hyperopia), optical instruments, Snell's window

Further information:

Link to the AHHAA worksheet: http://bit.ly/2IIdxbW

Hidden objects (2/2)

Explanation

A glass object in a glass filled with water is a rather regular sight. The image is slightly distorted—the glass object looks a bit larger in the water. This phenomenon is due to the speed of light in different environments. In this case, we have three environments (i.e. materials): air, water and glass. The sparser the medium, the quicker light moves in it and vice versa. Light refracts (and mirrors) on the boundary of two different optical environments, i.e. its speed changes. When moving from a sparser environment to a denser one (e.g. from air to glass), light refracts towards the surface normal. When moving from denser environment to a sparser one (e.g. from glass to water), light refracts away from the surface normal. This is the reason why the glass object can be seen clearly in a glass filled with water.

The refractive index of an optical environment is a number that shows how many times the speed of light in the respective environment differs from the speed of light in vacuum.

$N = \sin \alpha / \sin \gamma$

n – refractive index

α – angle of incidence

γ – angle of refraction

If we put a piece of glass in a glass filled with glycerine or cooking oil, it becomes invisible.

In such a situation, there are still three environments: air, glycerine/cooking oil and glass. Since the refractive indices of the two environments are the same (glass and glycerine/cooking oil), the viewer cannot discern the glass object in the water: the glass seems to hold only liquid. Glass and glycerine/cooking oil have similar refractive indices ($n \approx 1.5$) and light moves at nearly the same speed in both environments without refracting noticeably on the boundary of the two materials.

Link to the teacher guide:
http://bit.ly/2Xmqsti

Link to the video tutorial:
https://youtu.be/mkKfM0z8UHY

QR code

Magnetic train (1/1)

Learning scenario

Divide the class into groups of 4 kids and give them the materials for the experiment. Work with them during the activity.

First, make a U shape wire and put it close to the compass, next try the same with the edges of the wire attached to the poles of the battery. The magnetic needle of the compass is moving the second time, because, when there is an electric current in a wire then a magnetic field is produced.

Second, create a copper coil by turning the wire around a cylindrical object. Once that's done, remove the cylinder from inside the coil, while being careful not to bend it.

Third, specify the polarity of the magnets with the help of the compass. Create a table with all the combinations with the directions of the magnets attached to the battery and also the direction of the battery, eight combinations in total.

Fourth, attach the two magnets to the ends of the battery cell, according to the first arrangement of the table. Ask the students to place the battery inside the coil from both edges and check to see if the battery with the magnets attached can pass freely through the coil.

Fifth, repeat the above for each arrangement and fill in the table by observing its behavior. Try to explain when and why the battery is moving and make a conclusion for the phenomenon.

Explanation

When the battery apparatus is placed inside the coil, its terminals make contact with the copper wire surrounding it. Thus, a closed circuit is created and current passes through the coil around the battery. As a result, the copper wire acts as an electromagnet. More precisely, a solenoid, since it's wound in a helical shape. The denser the loops, the stronger the magnetic field inside it becomes. The two permanent magnets at the ends of the battery create a magnetic field of their own, too. Depending on their arrangement, the magnetic fields of the permanent magnets and the solenoid might be parallel, antiparallel, or cancel each other out.

Duration: 45 minutes;

Objectives: to make a moving object using electromagnetic means;

Covered subjects: Physics, Polarity, Solenoid field, Electromagnetism;

Topics: Solenoid field from Ampere's law and the interaction between the electric and the magnetic fields;

Target group: students aged 14-17 years;

Materials: Uninsulated copper wire, batteries, ring neodymium magnets, compass, cylinder shape;

Words for internet search: Electromagnet, Magnetic Solenoid, Lorentz force, Ampere's Law;

Further information: http://bit.ly/2ILv8jg

http://bit.ly/2FeGMCf

Link to the video tutorial: https://youtu.be/WAWhDZ-fv_U

QR code

Acid rain (1/2)

Learning scenario

Divide the class into groups of 3-4 kids and give them the materials for the experiment. Work with them during the activity.

First, mark one jar "vinegar" and the other one "water."

Second, add 1 cup of vinegar into the vinegar jar. Place a paperclip, a piece of eggshell and a green leaf in the vinegar. Put the lid on the container.

Third, add 1 cup of water into the water jar. Place a paperclip, piece of eggshell and a green leaf in the distilled water. Put the lid on the container. Let the jars sit overnight on a windowsill or protected area.

Record your observations (a detailed description of what happened to each item) now, after one day in each solution and after two days in each solution.

Ask students to

• Describe what happened to the living items (the leaf and the eggshell) tested in the acidic solution (vinegar).

• Describe what happened to the non-living item (the paperclip) tested in the acidic solution (vinegar).

• Do you think acid rain has this effect on all living things?

• Do you think acid rain has this effect on all non-living things?

Explanation

Acid rain, or acid deposition, is a broad term that includes any form of precipitation with acidic components, such as sulphuric or nitric acid that falls to the ground from the atmosphere in wet or dry forms. This can include rain, snow, fog, hail or even dust that is acidic.

Acid rain results when sulphur dioxide (SO2) and nitrogen oxides (NOX) are emitted into the atmosphere and transported by wind and air currents. The SO2 and NOX react with water, oxygen and other chemicals to form sulphuric and nitric acids.

Duration: 45 minutes;

Objectives: to learn how acid rain is an air pollution problem that travels with the winds from west to east;

Covered subjects: chemistry, biology;

Topics: reactions of acids- acids and metals, acids and carbonates, acids and freshwater,
acid and soil, acid and plants;

Target group: students aged 12-18 years;

Materials: 2 small- or medium-sized glass jars, vinegar (acidic solution), water, 2 medium-sized eggshell pieces (carbonate salt), 2 small green leaves , 2 paperclips, masking tape and pen (for labeling containers), two 1.5-inch strips of wide-range (0-14 pH) litmus paper;

Words for internet search: Acid Rain, Nitrogen cycle, Human impact on the nitrogen cycle, and sulfur cycle;

Further information:

https://en.wikipedia.org/wiki/Acid_rain

Acid rain (2/2)

Explanation

Acid rain can be carried accross great distances in the atmosphere, not just between countries but also from continent to continent. The acid rain can also take the forms of snow, mists and dry dusts.

The rain sometimes falls many miles from the source of pollution but wherever it falls, it can have a serious effect on soil, trees, buildings and water.

Acid rain has been shown to have adverse impacts on forests, freshwater and soils, killing insects and aquatic life-forms, causing paints to peel, corrosion of steel structures such as bridges, and weathering of stone buildings and statues as well as having impacts on human health.

Link to the video tutorial:
https://youtu.be/Kdrk3ECT_m4

QR code

Music, Physics and Fun (1/2)

Learning scenario

Divide the class into groups of 5-6 kids and give them the materials for the experiment. Work with them during the activity.

First, choose two identical glasses and 6 different ones.

Second, you need a metallic, a wooden and a plastic object. How many experiments can you do?

Third, try to change the type of glass, the impact materials and the liquid.

Forth, fill the glass with water or oil and try to find the possible ways you can use to change the features of the sound.

Fifth, put in the glasses water or oil. Fill up the 1st, put less in the 2nd glass and so on until the last glass is almost empty.

Six, hit the glasses one by one with a spoon.

Ask students the questions:

- Which factors (TYPE OF GLASS, AMOUNT OF LIQUID, TYPE OF LIQUID, PERCUSSION OBJECT) affected the features (PITCH, TONE, VOLUME, DURATION) of the sound?
- Which intervals could you produce? (tone, half-tone, octave etc.)
- Which liquid produced the clearest sound? (Density VS Tone)
- Write a short musical phrase of 4 metres and try to play the melody below.

Explanation

An empty glass produces a higher sound than the full glass:

- Water has a different density than the oil and this influences the tone of the sound.
- The type of glass (glass, crystal, tall, short, wider or narrower) affect the sound quality.
- The metallic, plastic or wooden object and the force that we use to hit the glass produce higher or lower volume.

Duration: 45 minutes;

Objectives: to learn the features of the sound, to combine music with physics, to understand the meaning of frequency, density and width of oscillation;

Covered subjects: music and physics;

Topics: the features of the sound (Volume, pitch and tone), frequency, density and width of oscillation;

Target group: students aged 14-15 years;

Materials: 8 glasses (two identical ones and six different: tall, short, wider or narrower), oil, water, a metallic, a wooden and a plastic object, kitchen roll;

Words for internet search: Intensity, Duration, Frequency, Pitch, Density, Tone;

Further information:
https://en.wikipedia.org/wiki/Sound

Link to the video tutorial:
https://youtu.be/krGd0D09i6Q

QR code

Music, Physics and Fun (2/2)

Explanation

Music - to describe a sound, we use its four basic features:

- Pitch: the pitch is the feature of the sound that allows us to judge if a sound is acute or deep. It depends on the oscillation frequency of the sound source's oscillation.
- Tone: it refers to two sounds that have the same pitch and volume but they cause a different acoustic feeling. Every musical instrument and every human voice has a different tone.
- Volume: how loud is the sound? The intensity is measured in decibels (dB). The greater the sound of the sound source, the higher the sound wave. The intensity is the physical property of the wave that can be measured.
- Duration: it defines the time duration in which a sound is perceptible.

Physics - sound features are associated with the following concepts of physics:

- Frequency expresses the periodic oscillation and it is counted in cycles per second (Herz) (frequency and pitch).
- The density of each material (water, oil, honey) is different (density and tone).
- The width of oscillation expresses the total time for which a sound can be perceptible (Intensity and duration).

Osmosis (1/3)

Learning scenario

Task 1: The osmosis phenomenon in the potato tissue

1. Using the marker, number the test tubes on the base:

- Fill up the first tube approximately to the middle with deionized water;
- Fill up the second tube approximately to the middle with a 12% w/v sugar solution;
- Fill up the third tube approximately to the middle with a 34,2% w/v sugar solution;

2. Take three (3) clean potato pieces, of a rectangular parallelepiped of the same length, and about 1 cm thick each.

Carefully wipe the first piece with absorbent paper, weigh its mass and fill its value in the measurement table (initial potato mass column). Then immerse the piece in the solution of the first test tube.

Weigh the mass of the second piece, write down its value in the measurement table and immerse the piece in the second test tube solution.

Repeat the same procedure for the third piece.

Leave the pieces in the test tubes for 30 minutes.

3. Using a forcep remove the potato pieces from the test tubes and place them in a row on kitchen paper. Wipe each piece carefully using absorbent paper.

4. Weigh each piece and fill in the data in the measurement table (final potato mass column).

Test tube	Concentration of sugar solution	Initial potato mass (m_{init})	Final potato mass (m_{fin})	$\Delta m = m_{fin} - m_{init}$
1st	0,00 M (deionized water)			
2nd	0,35 M			
3rd	1,00 M			

Duration: 60 minutes;

Objectives: To observe the Osmosis phenomenon:
a) macroscopically
b) microscopically

Covered subjects: Chemistry, Biology;

Topics: solution, hypertonic, hypotonic, semi-permeable membrane, plant cell, microscope, plasmolysis;

Target group: students aged 15-18 years;

Materials: microscope, precision scale, test tubes, lugol solution, saline solution, deionized water, 0,35 ml and 1 ml sugar solutions, fresh potato sticks, a piece of onion;

Words for internet search: Osmosis;

Further information: https://en.wikipedia.org/wiki/Osmosis

Link to the video tutorial: https://youtu.be/0_FKNC51o9o

QR code

Osmosis (2/3)

Task 2: Observation of onion plant cells under normal conditions and in plasmolysis state

1. Take a thin film from the bulb of an onion and keep it in order to see its interior. With the scalpel, cut carefully two small pieces of the thin film, inside of the onion, measuring approximately 2x2 cm.

2. Using the tweezer, remove the thin film, making sure that you do not drag tissue from the underside.

3. Place each piece of the film on the same microscope slide (near the edges) taking care not to fold it. If this happens, we straighten it with an anatomic needle.

4. Pour one drop of the Lugol solution (dye) onto one film and leave it for 2-3 minutes (1st preparation)

5. Pour onto the other film a few drops of the saline solution (25%) to cover the film and wait for 3-5 minutes. Then add a drop of the Lugol solution (dye) and leave it for 2-3 minutes (2nd preparation)

6. Cover carefully each preparation with a coverslip so that no bubbles are created, otherwise lightly press the coverslip. Wipe the liquid that comes out of the coverslip with filter paper.

Explanation

Osmosis is the phenomenon of passing more solvent molecules, through a semi-permeable membrane, from the solvent to the solution, or from a less concentrated (hypotonic) to a higher concentrated solution (hypertonic).

Semi-permeable membrane allows the solvent molecules to pass through the pores, but it does not allow the molecules or ions of the solute to pass. Semi-permeable membranes can be natural (e.g., cellular membrane) or synthetic (e.g., cellophane).

The pores of these membranes are generally less than 250 nm. Many natural, in particular, animal membranes (cysts) can be used as semi-permeable membranes.

Osmosis (3/3)

Explanation

Importance of Osmosis in Life:

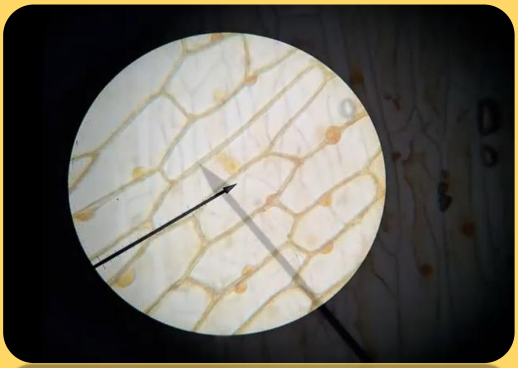
The phenomenon of osmosis plays an important role in many biological phenomena associated with cell function. The cells contain molecules of organic compounds (eg., proteins, salts) in the form of aqueous solution. Their cell membranes are semi-permeable and totally restrict or prevent the passage of substances that are large in size.

Thus, when a plant cell is immersed in water, which is considered a hypotonic solution, its volume increases due to the inlet of water inside it, due to osmosis. This phenomenon of plant cell swelling is called turgidity.

When the plant cell is found in a hypertonic solution, water will emerge from the cell, resulting in cell shrinkage. This phenomenon is called plasmolysis.

Approximately the same phenomena occurs in animal cells, but it is more intense. Animal cells in hypertonic solutions shrink, instead, in hypotonic solutions, animal cells swell. If swelling occurs to a large extent, it can eventually cause the destruction of animal cells.

Thus intravenous injection of hypotonic solution is very dangerous because it can cause swelling and rupture of red blood cells. This phenomenon is called hemolysis. If red blood cells are placed in isotonic sodium chloride (NaCl) solution of 9 %o, they maintain their shape and size.



Reducing friction (1/1)

Learning scenario

Divide the class into groups of 3-4 kids and give them the materials for the experiment. Work with them during the activity.

First, every group will make a construction based on CD or on DVD to which we attach the mouthpiece and adjust an inflated balloon.

Then let the balloon deflate by creating a layer of air between the CD and the surface.

We move the CD on the surface while the balloon is deflated and we see what happens with the CD.

We can repeat the same experiment with oil on the surface.

Ask students to:

- Describe what happened to the move of CDs on the table, while the balloons puffing.
- Describe what happened to the move of CDs on the table, when the surface is clear and what is happened when the surface is oiled.
- What do you think about the friction at all these cases?

Explanation

Friction is a force that resists movement of a body relative to another when they are in contact. It is a force exerted on the surface between the two bodies and is marked for each body as opposed to its movement.

Friction is omnipresent and virtually not apparent. Because of this power we can walk, climb, run, eat without sliding food, play strings, write, erase etc.

Imagine a world without friction in which we cannot do anything of the above because virtually friction is the cause of the normal motion and balance of materials in nature.

Many times we need to reduce the friction between the bodies and this can be achieved in many ways, one of which we explain in the experiment we have organized in this topic.

Duration: 40 minutes;

Objectives: learn about friction and how they will reduce it;

Covered subjects: physics;

Topics: friction, reduce friction, factors of friction;

Target group: students aged 12-18 years;

Materials: Oil, many CDs or DVDs, many balloons, a clear table with big surface, many mouthpieces from plastic bottles and a bottle with strong glue;

Words for internet search: Factors of friction, surfaces, movements;

Further information: https://en.wikipedia.org/wiki/Friction-factors_of_friction

Link to the video tutorial: https://youtu.be/gIDV1shvOGM

QR code

CONCLUSIONS

This report is the result of a 2-year project made of collaborations, exchange of best practices, learning experiences in different cultures with different ways of teaching science.

We really hope this report will support you in dealing with more engaging STEM activities at school and in making your students putting their hands on science!

For more information and collaborations, visit our Facebook Page

https://www.facebook.com/boostingscienceatschool/

You can also register to the Youtube channel

https://www.youtube.com/boostingscience

or, contact the project partners which will be more than happy to help you boost your science classes.