THE EUROPEAN PLATFORM FOR SCIENCE TEACHERS

SCIENCE ON STAGE
GERMANY

Teaching Science in Europe 4

iStage

Developing Teaching Materials for ICT (Information and Communications Technologies) in Natural Sciences

What European teachers can learn from each other

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Teaching Science in Europe 4

iStage

Developing Teaching Materials for ICT (Information and Communications Technology) in Natural Sciences

What European teachers can learn from each other

Under the guidance of the non-profit association Science on Stage Germany, and supported by SAP, 22 teachers from 14 European countries and Canada developed concepts and materials for science lessons.

THE EUROPEAN PLATFORM FOR SCIENCE TEACHERS

SCIENCE ON STAGE GERMANY

Content

Greeting EU-Commissioner Neelie Kroes

We live in a digital world. New devices, new services have changed the way we access and share information, the way we communicate, the way we work. It hasn't, however, drastically changed the way our youngsters learn and acquire new skills, be it in schools or at university. This is particularly unfortunate in the domain of science, since we are missing the opportunity to educate our youth in one of the disciplines, for which there is a clear shortage of trained people right now, and in the future.

I am engaged in enhancing digital literacy and competence to face the challenges of the future. Students need to be educated as science-active citizens to face the challenges of today's knowledge-based society and economy. Young talent is essential for the European economy to be successful, to be able to close the skills gaps and combat the mismatches that can threaten Europe's future labour supply. We need new insights to foster the sharing of ideas, to promote best practises. Innovative classroom teaching using ICT (information and communications technology) is vital for stimulating students' minds. Pedagogical practices based on inquiry-based methods are more effective than the traditional ones. Teachers should serve as guides who help define suitable paths and strategies for learning, leading students in a quest for locating information, questioning it, understanding it, and applying it.

The project "Teaching Science in Europe – Developing new Teaching Materials for the Use of ICT in the Natural Sciences" by Science on Stage Germany and SAP is particularly commendable. I very much support the approach of educating and motivating teachers as the best way forward. All studies and research conclude that teachers are the best assets we have for educating people. They are the ones who can best motivate our students and attract our youngsters to science. I am convinced that through a more systematic use of ICT in science classes, the material in this brochure will help teachers make science more appealing to students.

NEELIE KROES
Commissioner for the Digital Agenda

Greeting SAP

Education does not only offer endless possibilities, it is also a cause we all share. In a knowledge-based society, education is the basis for growth and employment. Only solid know-how allows us to remain innovative and our economies competitive.

As a software company we experience this every day. To be capable of developing our products, we need highly qualified employees. We perpetually invest in their further education and training. However, there is still a lack of well-trained employees who are able to persevere in a work environment that is becoming increasingly more complex. This is an obstacle for growth and progress, and not only for industry, but also for society as a whole.

Employees specialised in STEM subjects (science, technology, engineering, and mathematics) are particularly hard to find: According to the Cologne Institute for Economic Research (Institut der deutschen Wirtschaft Köln), there are, for example, 70,000 vacancies in the STEM sector in Germany. In addition to that, the ICT (information and communications technology) arena is lacking more than 38,000 experts and the numbers are growing. That is why it is our common corporative task to spark children's interest in technology and engineering at an early stage. SAP supports this approach in many ways; through our engagement in the FIRST LEGO League (FLL), or with projects such as erp4school, which introduces young people to the world of modern corporate processes.

It has been our pleasure to provide the means to realise the project by Science on Stage Germany. It is SAP's goal to trigger young people's enthusiasm as early as possible. The fact that these materials were developed by teachers for teachers makes them even more suitable for applied learning – independent of the school's facilities and location. I wish all teachers in Europe an inspiring read that helps them to design attractive and exciting lessons. I hope that this material manages to spark a wide interest in science in their students.

We cordially thank all members of the ICT working groups of Science on Stage Germany for their tireless and enthusiastic engagement in developing these materials.

MICHAEL KLEINEMEIER
Regional President Middle and Eastern Europe
SAP

Teaching Science in Europe – iStage

Paris. September 2011: A small group of science teachers from all over Europe and Canada meets to discuss their ideas on teaching. They go back home and continue the exchange via email. But then, they have their next meeting: February 2012 in Berlin!

It is this continuous, personal exchange of ideas between European teachers that makes "Teaching Science in Europe" so special. The non-profit organisation Science on Stage Germany organises this exceptional teacher training around different topics (see Teaching Science in Europe I to III). This time, their topic is called "iStage". The competent partner enabling the project is SAP.

The group of approximately 22 people from 15 different countries met each other for the first time in Paris. Here they exchanged their views on teaching Natural Sciences with the help of information and communications technology (ICT). This group of people was heterogeneous and diverse in many ways: They teach biology, chemistry, or physics. Their national or local curricula are different. Their ideas on didactics and methodology differ from each other, and they have very different backgrounds in computing – some of them none at all.

The coordinators, too, have different scientific and national backgrounds, but they agree on their shared goal: to encourage and help European teachers to use programming in their teaching. The word, which participants coined for the whole process, is "iStage". iStage is also the title of this publication by Science on Stage Germany, and it is available as an iBook too.

From a constructivist point of view, it is a great concept to get science students in secondary school to learn solving scientific problems by (re-)constructing the solution on a computer. Using computers offers a wide variety of tools that will advance and deepen an understanding of physics, chemistry, and biology. However, this notion is a remote reality in European schools, since most science teachers are not trained in computer sciences. So, a first goal must be to invite teachers to actually work with computer programs by themselves, or get help from local experts. The next step is to have teachers assign their students the job of "constructing" a program. To achieve this particular goal, participants exchanged ideas for teaching units, which lend themselves to including ICT and especially programming in their classes.

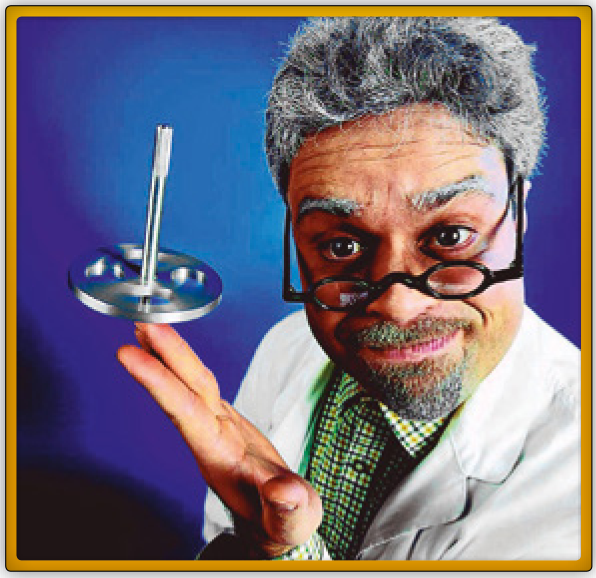

Image courtesy of Wolfgang Herzberg

Additionally, the coordinators tried to encourage participants to include hands-on programming in each teaching unit. Ideally, a teaching unit would include students coding a program. Some of our teaching units actually do. In any case, for now, we are very happy to have encouraged most teachers to program something for their students. In the following chapters, participants describe the teaching units themselves.

During the long process of iStage, the participants discovered different tools, which they used in their teaching units, and which they would like to recommend to their European colleagues. We prefer open source or freeware

Acknowledgments

Science on Stage Germany would like to give special thanks to all participants for their enormous commitment. The teachers involved in this project spent a lot of time and energy on their teaching units, and they did this while still performing their regular jobs. This is an exceptional contribution!

The events, this publication, and the dissemination of the results would not have been possible without the generous support of SAP. All participants and the organiser are extremely grateful for this aid!

software like “Tracker” (for video analysis), a simple but powerful programming language “Scratch”, java libraries like “Open Source Physics (OSP)” or “Stifte und Mäuse (SuM)”, and a tool called “Easy Java Simulations (EJS)”. All of these software are free, and all claim to work on almost any computer-operating system. Our programming experts Jürgen Czischke and Bernhard Schriek described these tools in the annex.

Bearing in mind the aim to encourage teachers to code programs, some of whom have never programmed before, it is only natural that the teaching units presented here, and the programs developed alongside, are by no means complete or perfect. Our goal is to start the process, not to present a finished product. We will continue to do so long after this publication goes out. On that note: iStage should be considered as a work in progress, by teachers for teachers.

DR. JÖRG GUTSCHANK
Leibniz Gymnasium | Dortmund International School
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Board member Science on Stage Germany
Main Coordinator

Biology and Health

This section presents three projects illustrating the use of information and communications technology (ICT) to study three different aspects of biology: genetics, plant growth, and diet and exercise.

Biological processes are characterised by their complexity at very different levels in time and space. In the short spatiotemporal scale, cells have tiny sizes as small as a thousandth of a millimetre. They contain hundreds of different molecules interacting with each other to use nutrients. They can rapidly react to the environment in a fraction of a second. They create other cells. On the long spatiotemporal scale, huge communities of millions of species interact at the ecological level of oceans and continents, and have evolved during hundreds of millions of years.

The existence of the large spatiotemporal scale might make impossible the realisation of an experiment. For example, the spreading of a gene variant in a population of one animal species can take many generations. If this population has many members distributed across several kilometres of land, it is not possible to find and examine all of these animals in order to see whether they have inherited a gene variant from their parents or not. In such cases, using a model from a computer simulation that simulates the passing of time at an accelerated pace, is a helpful tool. The first teaching unit "Brer Rabbit, Rare Rabbit" demonstrates an effect known as Hardy-Weinberg Equilibrium, which means the frequency of an allele in a population remains constant unless a perturbation is introduced. The program simulates a model population. The students learn the value of numerical simulation to explain a genetic model of inheritance.

"Plant growth" illustrates how ICT can be used to study and quantify parameters in a biological experiment accessible to students by following the conditions that influence the sprouting and growth of a plant. They can use a program or spread sheet to compare growth profiles and enter them in a continuous growth chart. This teaching unit shows that quantification in biology is a necessary step that can lead to proving or disproving a hypothesis. It also demonstrates that a biologist has to make sure the reference quantity chosen is directly connected to the biological property that is being observed, and that other conditions that could influence the observed subject have to be controlled.

The unit "Don't Worry, Be Healthy" illustrates that one of the most important contributions of biological research is that it may lead us to live longer and healthier lives. This unit requires students to observe their nutritional and exercise habits for the period of one week. Based on an underlying database, a computer program calculates the energy input from food, and the energy output from both basal metabolic rate and exercise. In this case, besides gaining an understanding of metabolism and nutrition, the students may draw conclusions that lead them to live healthier lives.

By proposing computational applications in genetics, plant biology, and diet, these three units illustrate how biology benefits from computation at very different levels, in this case using three different approaches: modelling, experimental analysis, and the collection of clinical data.

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Max Delbrück Center for Molecular Medicine
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Coordinator

Philipp Gebhardt · Richard Spencer

A

Brer Rabbit, Rare Rabbit

Directional Selection, Allele Frequencies and Evolution

INTRODUCTION

Key concepts:
Monohybrid; Mendelian cross; genotype; homozygous; heterozygous; dominant; recessive; phenotype; directional selection; evolution; gene pool; allele frequency; Hardy-Weinberg Principle; carrying capacity.

This simulation activity is aimed at students aged 16 – 18 years studying Advanced Level Biology. It is designed to help them understand the following core principles related to the study of allele frequency in a gene pool:

- Inheritance of dominant and recessive alleles in monohybrid Mendelian crosses.
- The reason why allele frequencies remain more-or-less constant in an environment where there is no selection pressure for particular phenotypes.
- How the Hardy-Weinberg Principle can be applied to calculate the allele frequency for dominant and recessive alleles of a phenotype controlled by two alleles of a single gene, and amongst a population of individuals in which there is no selective advantage for any given phenotype.
- Evolution is a change in allele frequencies in a population over a period of time.
- The reason why allele frequencies change in an environment where there is directional selection, the latter of which favours the survival of individuals with a particular phenotype.
- The reason why retention of disadvantageous alleles in a gene pool is desirable in terms of a species' ability to adapt to potential changes in the environment.

The simulation adapts and develops some of the principles reported in the article "Counting Buttons: demonstrating the Hardy-Weinberg principle" *(Pongsophon, Roadrangka and Campbell; Science in School; Issue 6: Autumn 2007)*.

RESOURCES

The activity can be accessed online on the EMBLog teachers' portal hosted by the European Learning Laboratory for the Life Sciences at the EMBL. The program to carry out the activity has been developed using Flash-based SAP Xcelsius software.

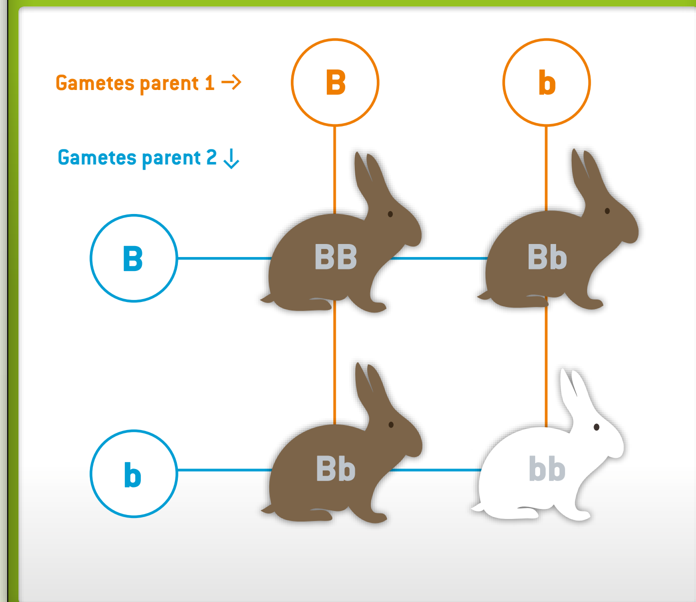
Via www.science-on-stage.de you will get to the EMBLog teachers' portal (you have to register to access the content).

CORE

Allele Frequency: No Selection
Students are presented with background information about a model population of 64 rabbits in which there are two alleles for coat colour, brown *(B)* and white *(b)*. The allele for brown coat colour is dominant over the allele for white coat colour, so that rabbits of genotype *BB* and *Bb* have brown fur whereas those of genotype bb have white fur. The allele for fur colour is inherited in a straightforward monohybrid Mendelian fashion, and given the dominance of the allele for brown fur, brown rabbits outnumber white rabbits at a ratio of 3:1. Therefore, the initial population of 64 rabbits has 16 rabbits of homozygous genotype *BB*, 32 rabbits of heterozygous genotype *Bb* and 16 rabbits of homozygous genotype bb.

The rabbits live in a habitat, which is covered by vegetation for some of the year and covered by snow for the rest of the year. Rabbits with brown fur are better camouflaged in vegetation, whereas rabbits with white fur are better camouflaged in snow. On balance, there is no advantage or disadvantage to having either brown or white fur.

Punnet square



To remind students how a Mendelian monohybrid cross works, students use an interactive Punnett square to simulate a genetic cross between two heterozygous *(Bb)* rabbits.

Students then use the program to find out the genotypes of all the offspring of the starting population. The program factors in four assumptions: firstly, there is random mating between the parent rabbits of different genotypes; secondly, the carrying capacity of the habitat is 64 rabbits; thirdly, an equal proportion (50 %) of offspring of all three genotypes will survive to reproduce; finally, the offspring of the first generation that survive to maturity become the parents of the next generation.

The program guides students so they are able to discover the numbers of offspring of each genotype over ten generations. This information is used to calculate the frequencies of alleles *B* and *b* in each generation. To make sure that students understand how allele frequencies are derived, they are required to make a sample calculation by entering data and checking whether it yields the correct answer.

Students discover that the frequencies of alleles *B* and *b* remain more or less constant. The program is designed to display the output data (allele frequency against generation number) in a graph.

Allele Frequency: Hardy-Weinberg Principle

In the rabbit population, rabbits of genotype *BB* and *Bb* look the same (brown fur), so it is not possible to work out the number of individuals of each genotype. However, the numbers of rabbits of genotype bb can be recognised and counted (they all have white fur). The activity leads students through the theory underpinning the Hardy-Weinberg Principle, to show how the number of rabbits of genotype *bb* can be used to estimate the numbers of rabbits of genotypes *BB* and *Bb* respectively.

Students are required to apply the Hardy-Weinberg Principle to a given problem. By inputting the relevant data selected from the information provided, they are able to analyse the information to calculate the estimated number of rabbits of genotypes *BB* and *Bb* in a given population in which the number of rabbits of genotype *bb* is known. Hints are provided to lead the students through the calculations, and there is also a provision to check that the calculations have been done correctly.

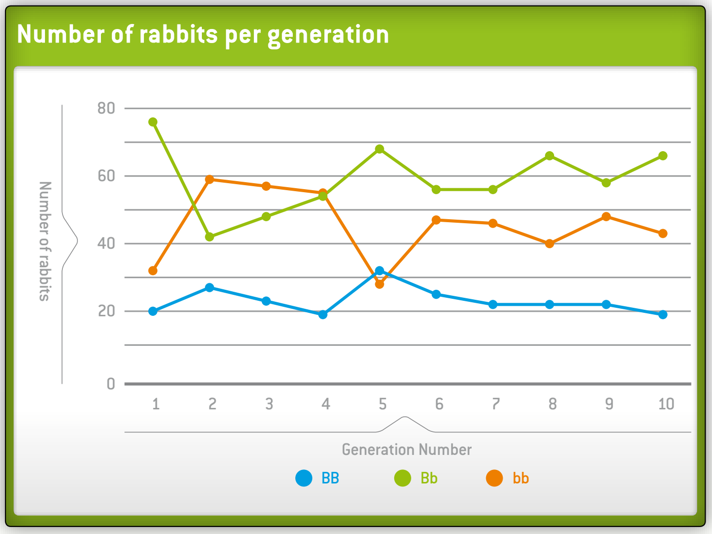
Allele Frequency: Selection

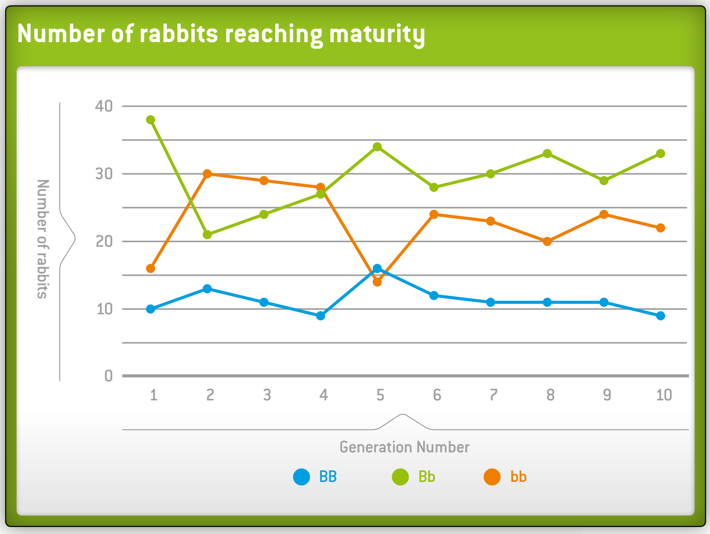
As a result of climate change, the habitat is no longer covered by snow for any part of the year. This puts white rabbits (genotype *bb*) at a disadvantage. They are no longer camouflaged in a habitat, which is covered by vegetation all-year-round, and are much more prone to predation. White fur is a disadvantage now: All rabbits of white fur are predated before they reach maturity. The environment selects against them.

As for “No Selection”, students use the program to find out the genotypes of all the offspring of the starting population and subsequent generations. However, this time the parameters have changed. The program factors in three of the previous four assumptions (random mating between the parent rabbits of different genotypes; carrying capacity of the habitat is 64 rabbits; offspring of one generation, which survive to maturity, become the parents of the next generation). But note, there is one key difference: the proportion of offspring of all three genotypes, which survive to reproduce, is no longer equal, because none of the white rabbits reach maturity. The program takes this into account, and applies adjustment equations to calculate how many of the rabbits of genotypes *BB* and *Bb* reach maturity to become parents of the next generation. This will be above 50 %, but the actual percentage depends on the numbers of rabbits of genotype *bb* born into each generation.

As for the “No Selection” scenario, the program guides students so they are able to discover the numbers of offspring of each genotype over ten generations. This information is used to calculate the frequencies of alleles *B* and *b* in each generation.

Students discover that the frequencies of alleles *B* and *b* change from one generation to the next (frequency of allele *B* increases, whereas frequency of allele b decreases). The program is designed to visualise the output data (allele frequency against generation number) in a graph.





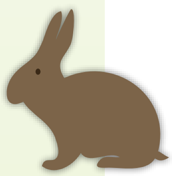
Questions to Summarise Key Concepts

The final part of the activity is a set of questions. Completion of these questions provides evidence that students have completed the activity and helps the teacher to check students' understanding of the key concepts, which underpin it. Students enter their answers to the questions and also their name and date. They print out their responses and return them to their teacher for marking.

CONCLUSION

This simulation activity can be accessed online. It could be completed within lesson time, or it could be given as homework or as a self-study assignment. Students check their own learning by completing a multiple-choice quiz at the end of the activity, which is marked by the program. In addition, a set of questions is supplied for students to complete and print out. Should teachers want to assess how well students understand the key concepts covered by this simulation, they can use these traditional exam-style questions.

We would appreciate your feedback on this activity, including any suggestions for improvement. A mark scheme to the exam-style questions can be supplied on request. Contact: richard.spencer@stockton.ac.uk



Anna Körbisch · Márta Gajdosné Szabó

A

Plant Growth – The Life of Bernd the Bean

INTRODUCTION

The teaching unit „The Life of Bernd the Bean“ deals with the topics germination and plant growth.

Key concepts:
Anatomy and physiology of plant seeds, germination, performing a monitoring protocol, making morphological drawings.

Age:
14–16 years. Younger students surely also have fun with this set of experiments, but they need a higher level of support for the evaluation of the data.

In this example students learn about development, germination and growth. Bean seeds (Phaseolus coccineus) are investigated in the dry and swollen state and the changes are described. The conditions of germination will be determined with experiments under deficient conditions and then compared to a control experiment. An experimental protocol is applied. Particular consideration is given to the competence-oriented science. Students can organise knowledge by acquiring, displaying and communicating. Germination is described as a process in nature. Students have to use different media sources for technical information and present it in various forms. They learn to carry out observation processes about phenomena in nature, to take measurements and to describe them. The test results need to be captured, illustrated and interpreted. You should be able to detect dependencies (Competency Model Science in Grade 8, Austria, 2011/ Kompetenzmodell Naturwissenschaften 8. Schulstufe, Österreich 2011).

List of materials:
Phaseolus coccineus, pots, soil, petri dishes, a magnifying glass, binoculars, a smartphone, a camera, a PC with internet access, paper, pencils, overhead pen, a spray bottle.

Before students can describe these experimental series in a long-term log, the supervisor must first create a wiki with a title.

Useful link: www.wikia.org.

RESOURCES

The measurement results are presented in various forms on the basis of calculation programs.

For the protocol, the different growth phases are photographed and recorded in the form of photo documentation. Based on records of the analysed test results, the student groups each compile a wiki for the project on „Plant Growth“ together.

- Use of smart phones (for obtaining information, photo documentation).
- Growth measurement of a bean plant by way of photographs that show growth in motion (e.g. with the free online service “Animoto” that allows you to make short films from photos).
- With the parameters of light, temperature and water, the germination and growth process can be visualised in an animation program (Scratch, see annex).
- Cartoon on the growth of Bernd the bean: toon-boom-studio.softonic.de.
- The components above are entered in the wiki and published.

CORE

Input
10 bean seeds are investigated. Each bean seed is placed, measured and photographed on graph paper in its dry state. The measurement results are recorded on a spread sheet. The average length and width is calculated. The swelling of the seeds is the starting point of germination. The bean seed must now be placed in water to start the process. The water absorption takes place through the micropyle. After 24 hours in the water, the swollen seeds are again measured and the average length and width calculated again. The values are compared.

For the germination tests dry (A series) and soaked seeds (B series) are used and handled according to precise instructions. The plant pots A1, B1 are placed in a box, A2, B2 in the fridge, A3, B3, A4 and B4 on the windowsill. All plant pots are watered with 25cm³ of tap water each day. (These approaches are only suggestions and students can try out other variations for themselves). The following parameters will be investigated: light-darkness germinators, dependence on temperature, and water demand.

During the following week, the students must look after the experiment carefully. Data should be collected daily and entered in the long-term protocol. As soon as the first shoots appear, it is important to document the growth in photos.

Output

In this long-term test students learn how to generate scientific knowledge. On the basis of a scientific inquiry, students learn through their own experiments. This will happen in accordance with detailed instructions during class. All data must be recorded carefully. On the one hand, this is achieved in the form of measured values, which are then presented in a spread sheet and analysed. On the other hand the students use photo documentation.

Students learn about the conditions of germination from these experiments. From the results they can read the parameters that affect the beans. Using the Scratch program (see annex), they also learn, for example, what the law of the minimum for organisms means. Students should counter-check the results obtained in experiments on germination and growth with a computer program.

The biological parameters that could be used here can be, for example: the temperature (T), the distance from the window (d), the amount of water needed per day (w), and the use of non-swollen or swollen seeds (yes / no). Students recognise plant height (h) as a function of time (t in days). The program requires the input of the constant „w“ and „h“ and then shows the estimated values of plant growth for ten days.

The students must try to determine an ideal combination of the conditions above that make the plants germinate better and grow faster.

This could look as follows:
$h(t) = k \times \frac{w}{d} \times t$

In this function, „t“ is the number of days for germination, „w“ is the need for water in cm^3, „d“ stands for the distance to the window, and „k“ stands for a constant that can be changed. The solution is the growth of height „h“ in centimetres (cm). Students can also add other factors and observe the effects on growth, and discuss the effects of these factors with each other.

CONCLUSION

The experiment of „The Life of Bernd the Bean“ provides experimental access to important topics such as germination and plant growth. With a series of experiments, the growth conditions are investigated. Media, which dominates the lives of the students, is used for monitoring the obtained results. A wiki replaces the protocol. The process of „growth“, a movement unperceivable to the bare eye, can be visualized with the photographs made into a movie. An animated cartoon with the title character „Bernd the Bean“ supports creativity.

Janos Kapitany · Márta Gajdosné Szabó

A

Don't Worry, Be Healthy – Life Management

INTRODUCTION

Key concepts:
Nutrients, oxidation, digestion, the reason for energy needs, calories, weight, body control, diet, basic metabolic rate, carbohydrates, fats, proteins, minerals, vitamins.

This simulation activity is aimed at students aged 12–14 years studying basic level biology. It is designed to help students understand the connection between consumption, physical activity, and weight.

- Every part of our daily diet has an energy content, dependent on the molecular construction of the basic ingredients (lipids, carbohydrates, proteins, nucleic acids).
- The reason for the different energy levels of the particular food types is the varying composition of their basic molecular ingredients. It can be described as the weighed sum of the energy content of the different components.
- All of our daily physical activities are part of our daily energy consumption and these can also be described with thermodynamical values.
- The body uses energy for physical activity from the metabolic reactions of the basic molecules.
- The cause of increasing body weight and fat content is the imbalance of energy input versus energy output.
- The reason we measure both sides is to find the right balance between nutrition and physical activity in order to avoid health problems.

RESOURCES

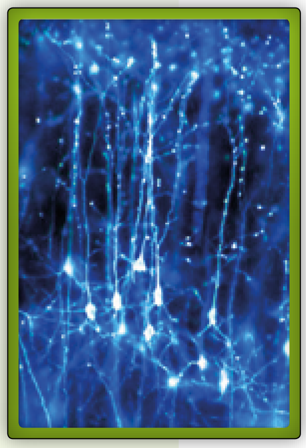
Our database: A detailed list of the energy content of the most common foods' raw components (cereals, vegetables, meat types, cheeses, etc.) and that of processed foods. It also contains the energy consumption rate of the most frequent daily (physical) activities. There are also questionnaires for monitoring the meal consumption (weekly diet) as well as actual physical activity logs. The program calculates a daily/weekly energy equilibrium rate from the comparison of energy input (food uptake) versus output (physical activity). The program and the detailed list of the energy content will be available at www.science-on-stage.de.

CORE

Life management is an interdisciplinary subject. With the help of this project we can teach biology, chemistry, physics, maths or ICT to our students. We recommend it for students aged 12–14 years. In Europe, subjects on diet or sports are always popular. We can make it interesting using many experiments and programs. In this project we focused on ICT, with the main parts called 'input', 'analysis' and 'output-visualisation'.

Relation to curriculum:
Biology, Physics, Chemistry, Maths and ICT.

Teaching part: from food to life
We need a lot of energy simply to live. We need energy for all of our movements, for a constant body temperature, to build our body, for our metabolism, even for brain activity.



We gain all this energy from the combustion of nutrients; more precisely, from the oxidation of the nutrients. First of all, the outside nutrients have to get into our cells. You've already learnt about this process – digestion – in previous classes. This unit is about energy needs, calories, foods, weight, body control, and diet. As everybody knows, there is a linear relationship between eating more and getting fatter. With this program you will get a clearer picture of how you can establish your food's energy content and the energy you consume during motion. After going through this program, you should be able to manage your weight long-term.

The Basic Metabolic Rate
Your body is burning energy all the time, not just when you are physically working or exercising, but even when you are resting or sleeping. The Basal Metabolic Rate (or BMR) works in the background of energy consumption, just to maintain your breathing, circulation and metabolism.

For most people the BMR accounts for the majority of the calories burned. As you get older, other things remaining

Photos · top: sxc.hu, Ezran Kamal · *bottom:* Rebecca-Lee's photostream, http://www.flickr.com/photos/lorelei-ranveig/2294885580/

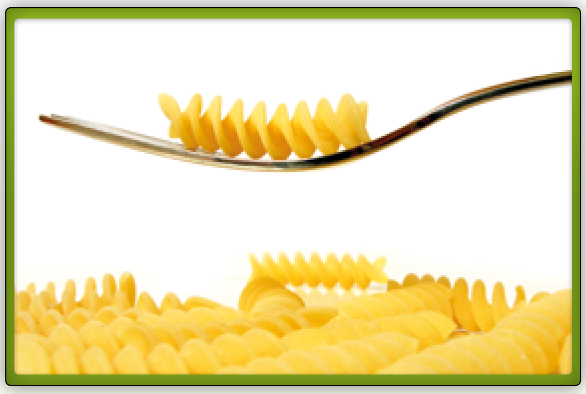
The inputs

The inputs are the variety of foods we eat. Foods are from nutrients. Let's have a look at them!

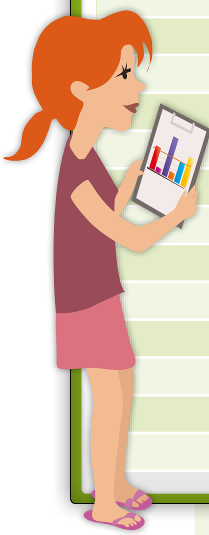
Kinds of nutrients

The foods we eat contain thousands of different chemicals. However, only a few dozen of these chemicals are absolutely essential to keeping us healthy. These are the nutrients - the substances we must obtain from the foods we consume. Nutritionists classify nutrients into six main groups: water, carbohydrates, fats, proteins, minerals, and vitamins.

constant, your BMR will decrease. The body controls the rate of metabolic energy consumption mainly through the hypothalamus, which is located in the brain stem. This process is completely autonomous, although it can be affected by our mood, stress or excitement, and also by the environment, while the body maintains a constant temperature.



The Basal Metabolic Rate



	kcal/day
female	
0–2	61 × body mass - 51
3–9	22.5 × body mass + 499
10–17	12.2 × body mass + 746
18–29	14.7 × body mass + 496
30–59	8.7 × body mass + 829
≥60	10.5 × body mass + 596
male	
0–2	60.9 × body mass - 54
3–9	22.7 × body mass + 495
10–17	17.5 × body mass + 651
18–29	15.3 × body mass + 679
30–59	11.6 × body mass + 879
≥60	13.5 × body mass + 487

The formula for BMR uses variables such as gender, height, weight and age to predict the speed at which we burn calories when at rest. It does not take into account your body fat composition. In reality, a person of a heavy muscular build will have a higher BMR than a person of the same weight, carrying more fat. The body requires an additional 16 calories a day for each pound of lean muscle, or 35 calories per kilogram. The difference in the formulae for men and women is mainly due to the different amounts of fat tissue in the bodies of males compared to females.

Carbohydrates include all sugars and starches. They serve as the main source of energy for living things. Each gram of carbohydrates provides about 4 calories (a gram is about 0.035 ounce). There are two kinds of carbohydrates - simple and complex. Simple carbohydrates, all of which are sugars, have a simple molecular structure. Complex carbohydrates, which include starches, have a larger and more complicated molecular structure that consists of many simple carbohydrates linked together.

Most foods contain carbohydrates. The main sugar in food is sucrose, which is the component of both ordinary white sugar and brown sugar.

Another important sugar – lactose – is found in milk. Fructose, an extremely sweet sugar, comes from most fruits and many vegetables. Foods containing starches include beans, breads, cereals, corn, pasta (macaroni, spaghetti, and similar foods made of flour), peas, and potatoes.

Fats are a highly concentrated source of energy. Each gram of fat provides about 9 calories, but you cannot live without it either.

Certain polyunsaturated fatty acids must be included in the diet because the body cannot manufacture them.

These essential fatty acids serve as building blocks for the membranes that surround every cell in the body. Polyunsaturated fatty acids are found in the oils of plants such as corn and soybeans as well as in fish such as salmon and mackerel. Common sources of monounsaturated fatty acids include olives and peanuts. Most saturated fatty acids are contained in foods derived from animals, such as butter, lard, dairy products, and fatty red meats.

Proteins provide energy. Like carbohydrates, they contain 4 calories per gram but more importantly, proteins serve as one of the main building blocks of the body. Muscle, skin, cartilage, and hair, for example, are made up largely of proteins. In addition, every cell contains proteins called enzymes, which speed up chemical reactions. Cells would not be able to function without these enzymes. Proteins also serve as hormones (chemical messengers) and as antibodies (disease-fighting chemicals).

The best dietary sources of protein are cheese, eggs, fish, lean meat, and milk. The proteins in these foods are called complete proteins because they contain adequate amounts of all the essential amino acids. Cereal grains, legumes (plants of the pea family), nuts, and vegetables also supply proteins. These proteins are called incomplete proteins because they lack adequate amounts of one or more of the essential amino acids.

Minerals and **vitamins** are very important for a healthy life, too, but our main focus is on energy input.

Calculating the energy value of food

The energy value signifies the calories contained in a certain food and is expressed in kJ. Our database contains the amount of energy in 100 g (or 100 cm^3) of food. Then you have to calculate how much energy is in the given amount of food. For example if the food's weight is 250 g, and 100 g means 1200 kJ, you have to multiply 1200 kJ by 2.5. If the food is not listed in the database you might find its energy per 100 g on its label. If you eat a homemade sandwich, you have to calculate all of its contents separately and then add them up. You can do this with a program.

Physical activities

Every kind of physical activity needs energy. Energy consumption depends on your body's condition, the intensity of your activity, and, of course, the amount of time you spend doing it. Some of the activities are hard to calculate, some (such as walking on a treadmill) are easier. With the program you can use our second database, which contains examples indicating the amount of kJ you burn per hour of activity.

Project homework

Please register your daily energy input and physical activity, subtract your BMR, and count your energy balance with the help of our program. Extend the databases of exercises and foods as needed.

Photos · top left: sxc.hu, Nathalie Dulex · *top right:* sxc.hu, Michael Connors · *bottom right:* inks: http://www.flickr.com/photos/slagheap/156249526/

CONCLUSION

The final step is to make a diet recommendation taking into account the energy provided by each food type. The recommendation is based upon the daily activity, the latter of which is entered in the questionnaire. It should contain the explanation of the diet, which is also entered (how healthy it is and why) and an explanation on the diet change based upon the nutrition recommendations.

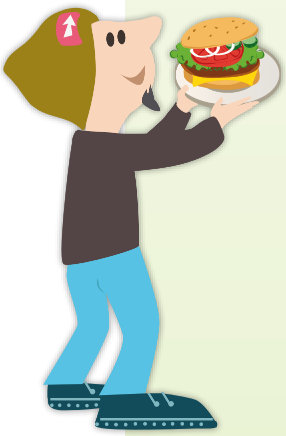


Photo · slworking2's photostream, http://www.flickr.com/photos/slworking/3640208323/

Our Environment

Taking care of our environment has become an essential part of science studies, since William Anders took the first earthrise picture during the Apollo 8 mission in 1968. This field of science is constantly discussed in the media and is very appealing to students. As it requires a lot of data collecting and processing, it is also a very good way to introduce ICT (information and communications technology) into a curriculum.

Environmental studies can take on many forms and cover many fields of science. During the process of making this booklet, the teachers decided to cover three main subjects: astronomy and the importance of the sun in our daily life, electromagnetic fields, and the control of monster rain. As our project involved small groups of teachers from many different countries working on every teaching unit together, the approaches are original and can easily be adapted to your own needs and curriculum.

In these units, ICT is used in different ways. A first approach is to use computer technology as a tool for collecting and sharing data. This is done in "Electromagnetic Fields of Low Frequency and Human Environment" where we use free online tools for creating questionnaires and compile data about the so-called electromagnetic smog.

Confronted with the dramatic effects of "Monster Rain" in Denmark, the subsequent teaching unit introduces students to the green roof, a method used in ancient times to capture the water and let it evaporate, instead of flooding the roads, caves and fields. For that purpose the students use Scratch (see annex) to build a simulation.

By using the same simulation approach, the last two units focus on the sun: "Length of the Day" and "Sun Exposition & Home Price". The students use a readymade Java program to simulate the path of the sun in the sky, or teachers help students create their own program for calculating the energy of the sun. In doing so, the students work towards the main goal of this publication.

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Coordinator

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B

Electromagnetic Fields of Low Frequency and Human Environment

INTRODUCTION

In nature, electromagnetic fields are a common occurrence. Natural electric and magnetic fields encompass the earth, its atmosphere, and the space surrounding the earth. Humans themselves are a source of electromagnetic fields of different frequencies as well. Apart from natural sources, there also exist artificial sources, which, supposedly, are not harmless to humans. The aim of this unit is to make our students aware of the omnipresence of these fields in our surroundings.

N.B.: According to the latest research, low electromagnetic radiation is considered to be harmless to the human body, compared to the high electromagnetic radiation of an X-ray or MRI. Nevertheless the so-called electromagnetic smog emitted, e.g. by mobile phones, is still a much-discussed issue in the public arena.

Key concepts:
Physics (magnets and electromagnets; Generator; Faraday's law; Maxwell's law; electromagnetic fields; radiation spectrum); Mathematics (Equation graphs); Environment (Environmental pollution)

Ages:
The unit is recommended for students aged 12 to 19 years.

- Ages 12–14: survey, measurements of magnetic-field induction and qualitative analysis
- Ages 15–19: survey, measurements of magnetic-field induction, quantitative analysis, preparing graphs.

RESOURCES

Graphics and questionnaires can be created using spread sheets, e.g. those by Microsoft Excel or Open Office.

There are free online tools for creating questionnaires, e.g. Google Docs (for documents and spread sheets).

You can take measurements using smart phones or PDAs (with electromagnetic field measuring capabilities). There are several apps available for free.

CORE

The following diagnostic and therapeutic instruments used in the medical arena can be a source of electromagnetic fields: X-ray apparatus, computer tomograph, magnetic resonator, instruments for magnetotherapy and magnetostimulation, and instruments for diathermy.

Further artificial sources are: power lines, radio and TV stations, radio-navigational and radiolocation instruments, mobile phones, any household-electrical devices. The condensation of these sources is referred to as electromagnetic smog.

In order to evaluate the average user's level of knowledge on electromagnetic fields of low frequency in these devices, 1,000 students were interviewed in a survey. The results turned out to be alarming. Only 14 % of those asked had a notion of what electromagnetic smog was and of those, only 5 % were able to define this notion correctly. To the question "Please mention electromagnetic sources known to you", 36 % of those asked could not give any answer. The other participants pointed out the devices listed in the questionnaire.

On the basis of questionnaires, we can create a ranking of these devices' harmful potential. In order to verify the validity of the ranking, we can measure the magnetic fields produced by these devices. For this purpose we used a field measurer in a smart phone, a PDA. The results of the measurements showed that the students' ranking was not correct.

Input
The general aim is to analyse electromagnetic fields in the human environment, and to raise students' awareness about this topic.

The students fill in a questionnaire on a computer. To simplify the data collection you can use a free online tool. In doing so, you can create a form. Students can access and fill in this form on the Internet, following a link. All of the collected data can be entered in a spread sheet, which you can download in the desired format. You can instant-


1

ly transform the results of the survey into percentages and graphs in a spread sheet. You can also create graphs in a spread sheet.

Afterwards, students measure the change of magnetic fields of different household devices (linear and three-dimensional). To do so, they use the geometer in the smart phone or PDA.

They measure the magnetic induction in 10cm intervals ① and enter the results in a table. The spread sheet plots the main graph.

Magnetic-field distribution measured on the plane (isolines). ② ③

Analysis

The students use the collected data from the survey and the measurements to plot graphs. The graphs are then discussed and analysed.

For example, when prompted to "please give examples of any sources of electromagnetic fields known to you", possible answers are "I know ...", "I don't know ...". A round graph can show the results.

For the question "Have you ever heard about 'electromagnetic smog'?", more than one answer is possible, so you can switch to bar graph.

Answers to the question "What appliances will, in your opinion, badly affect your health", can be presented in the graph y(x) (x – the name of the equipment; y – number of people).

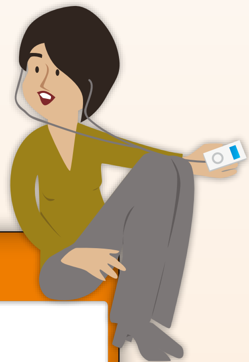
Students then can mathematically process the measurements (imprecise measuring instruments or imprecise human senses, e.g. sight, may cause some measurement inaccuracy). Results can be compiled in a spread sheet.

Example: "Magnitude of magnetic induction B [nT] of a certain piece of electric equipment (using students' own measurements) compared to the active distance marked with a colour". ④ ⑤

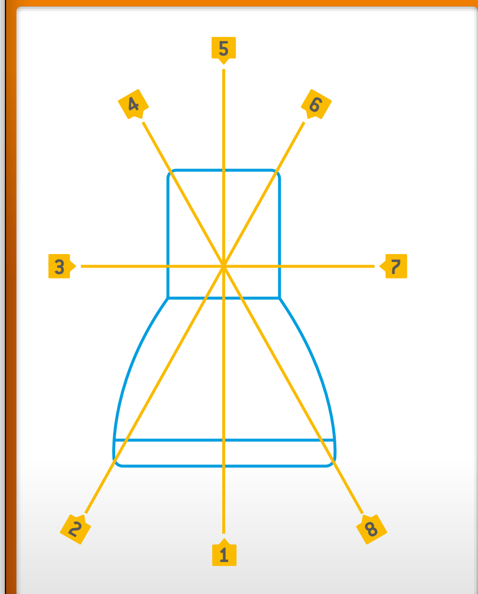
In concluding the analysis, they can compare the equipment's magnetic-field intensity and the exposure time (for example Graph y(x) :
x – the induction of magnetic field B[nT] and the exposure time t[h] – weekly dose ; y – the name of the equipment).

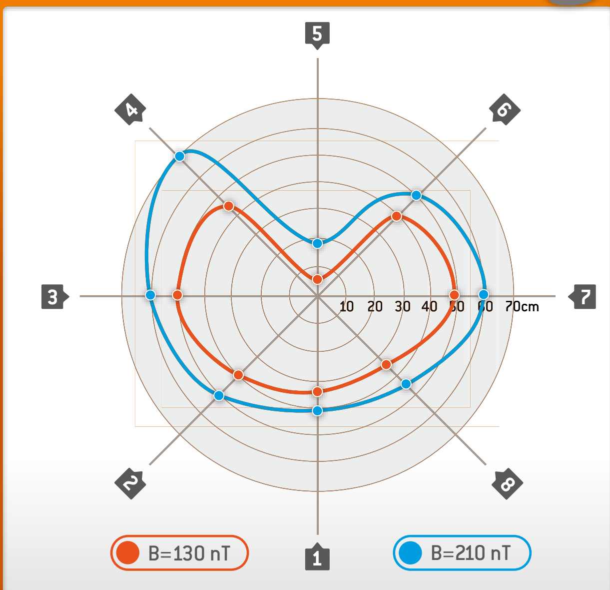
Output

The induction value of the devices' magnetic fields (usually given by manufacturers) as well as the exposure time are very important when it comes to analysing the influence of electromagnetic fields on humans.



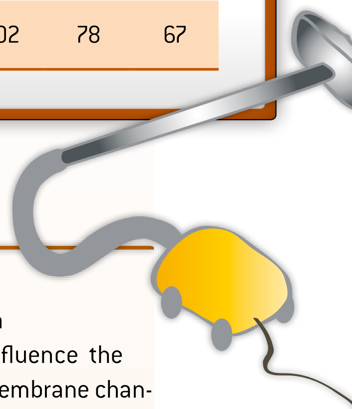
② ③ **Magnetic-field distribution measured on the plane (isolines)**





④ **Comparison of the magnitude of magnetic induction of certain pieces of electric equipment**

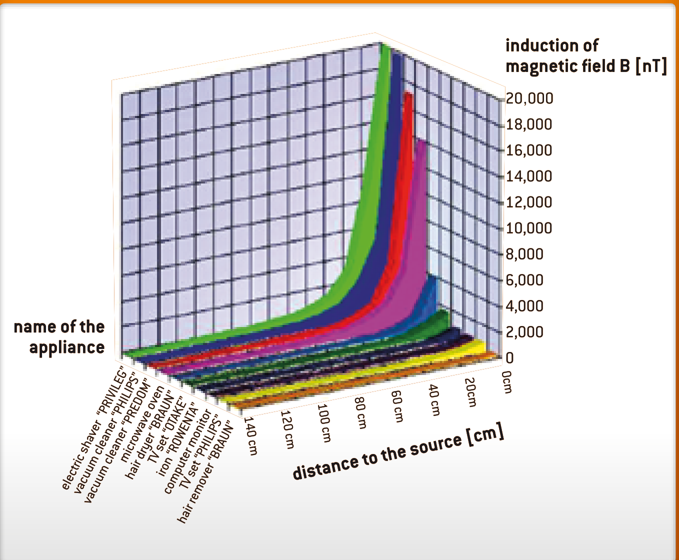
Distance to the source (cm) ❯	0	10	20	30	40	50	60	70	80	90	100	110	120
Vacuum cleaner „Philips“	19,755	5,695	2,560	1,200	754	461	331	247	187	162	136	109	103
Computer monitor	666	225	109	63	50	41	30						
Hair dryer „Braun“	3,940	1,043	464	206	133	85	69	51					
Shaver „Privileg“	19,980	9,450	3,320	1,432	844	500	341	232	180	127	102	78	67



The information on exposure of specific body parts is also very important. Students could discuss the results of the analysis, make posters for other students, and share their results with other classes, or surrounding schools. This could be done by using a common wiki or by disseminating the online questionnaire.

Additionally, a simulation of MRI exposure at phet.colorado.edu/en/simulation/mri can be helpful to understand how strong electromagnetic fields may affect the human body.

⑤ **Diagram of the dependence between the magnetic field's B [nT] induction and the distance [cm] for selected electric appliances**



CONCLUSION

Electromagnetic fields control many biological and physiological processes in the human body. For example, they influence the structure of the protein components of membrane channels and the distribution of ions. They affect liquid crystals contained in the body, especially those liquid crystal components of biological membranes.

The possible influence of low-frequency electromagnetic fields on the human environment is a crucial problem but, as the questionnaires have shown, generally not a well known one. Penetrating this problem of unawareness is a first step for presenting the subject to an average user of electric devices. The point is not to be afraid of electromagnetic fields, but not to disregard the problem either, and to make sure they are used in a proper fashion, e.g. avoid using many electrical devices at the same time; TV, computer, audio equipment; avoid spending lots of hours in front of a computer or TV screen; switch off Wi-Fi etc.).

Birthe Zimmermann · Michael Lentfer Jensen

Monster Rain – Monitoring the Climate

INTRODUCTION

Key concepts

Ecology: plant growth; water absorption; flow; plant structure and function, nutrients, C- and N- cycle; photosynthesis, respiration, fermentation, biotopes, succession; evolution.

Physics: modelling; making a simulation; flow measurements.

Monitoring the climate is recommended for students aged 14–18 (or younger) studying applied sciences while working interdisciplinarily in physics and biology. It triggers students' critical thinking abilities while allowing them to suggest and develop methods and experiments that involve local problems. Additionally, by increasing communication, it offers a regional and global understanding and perception of education on sustainable development.

RESOURCES

Modelling is fun! However, making a simulation that really works is a challenge. Remember that graphs are useful to present your results – far better than written explanations. Photos are also useful when communicating your work to others. When asked to simulate an experiment, you can use Scratch (see annex). When asked to draw graphs, you can find many programs on the Internet free of charge.

You find a monster rain simulation at scratch.mit.edu/projects/2352259/. Instructions how to construct a "monster rain" prototype can be found at www.science-on-stage.de.

CORE

This unit deals with the real world. The classroom can preferably be exchanged with outdoor monitoring opportunities: In recent years, climate change and global warming have led to increased local problems, e.g. droughts in some areas and very heavy rain in others. "Monster rain" is defined as large amounts of rain pouring down in very little time. Monster rain flows unexpectedly, and can cause floods that have a great impact on houses, railroad tracks and roads, which can be flooded or even washed away.

You can help monitor the effect of monster rain on a green roof by constructing a local miniature prototype. For the best results, you should continue measurements over a long period of time – months, or even years – if possible. You can register the flow and temperature online. Using information and communications technology (ICT) you can share your knowledge and ideas with others.

Use the Internet to find out and share:

- How much precipitation does your area get per year? Has the amount changed over the last, e.g. 50 years?
- Do you get severe storms and "monster rain" at certain times of the year? If so, when and how often in recent years?
- What happens to the rain that falls on the roof of your school or your home – where does it go?
- Are any measures taken in your local area to prevent damage from climate change such as floods? If so – what measures are taken?
- Are Sedum plants growing in your local area? In what kind of biotopes?

Student experiment: Absorption and flow

It is ideal if your school has a separate, rather flat roof with a single gutter and a single drainpipe that can be used for a large-scale, long term monitoring project. A flow meter can be used to measure the flow whenever it rains. Online registration of the data is possible. However, for the following measurements a small-scale model can be constructed and used for monitoring projects short-term and to compare with an "ordinary" roof.

To make your "green roof" model have a look at the additional material at www.science-on-stage.de.

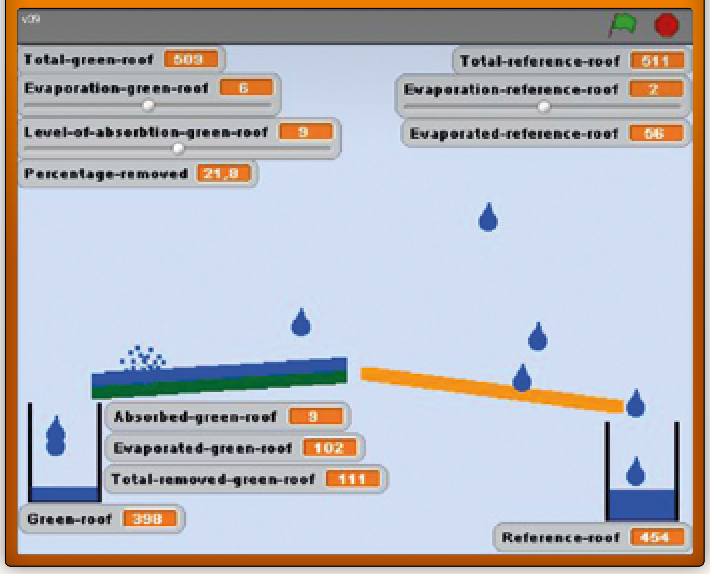
Measure length and width of your wooden pallets ("roofs") and calculate the total area in m^2 of "roofs" 1 and 2. Note the results.

Weigh each of the "roof" pallets 1 and 2 in dry condition. Note the results. Use a litre measure and slowly add water (tap water) to "roof 1" until it cannot absorb any more water and starts dripping a little. Note how much water you added to roof 1.

Pour the same volume of water onto "roof 2" and collect the run-off water from each roof. How much water ran down the drain from "roof 1"?

Note the volume of water that ran from both roofs. Repeat the monitoring daily, once a week, and if possible for a number of weeks.

Simulation of monster rain with Scratch



Programming

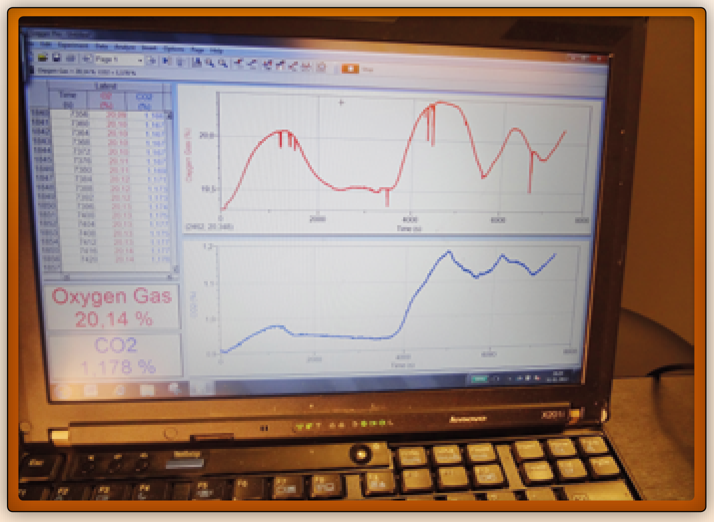
A fun and easy way to predict the outcome of an experiment is to create your own simulation by using the simple and free drag-and-drop programming software called Scratch (see annex). A teacher's guide for this monster-rain project can be found at www.science-on-stage.de. The monster-rain project will teach students to make a small animation of their own, allowing them to see how programming can be used to describe and make calculations in a simple physical system. The source code is available at www.science-on-stage.de.

The model can then be improved and extended for advanced students permitting them to take into consideration more complex parameters. A model where you can change the absorption and evaporation has been developed at scratch.mit.edu/projects/agsmj/2352259.

On evaporation

Useful data can be obtained by studying the Sedum plants in a growth chamber connected to an oxygen electrode and a carbon-dioxide electrode. Other data such as temperature and humidity can be measured simultaneously in order to observe how the effect of a green roof will vary with seasonal and local climate.

Make sure the plants adapt to conditions in the growth chamber by placing them there 24 hours before running the measurements. Data and graphs of O_2 and CO_2 collected and created over a period of, e.g. 24 hours or longer, with and without additional light, provide excellent parameters for analysis and discussion. The students may discuss the effect of evaporation with Sedum plants as a



means for reducing the water from monster rain or delaying the water from running down the drain. Thus, they will find rather simple solutions to diminish problems caused by climate change and global warming.

Students of advanced biology may use the collected data and graphs to study the photosynthesis of Sedum plants: the CAM photosynthesis.

Discussion questions to summarise the key concepts

The students can use their observed data to discuss how much water can be absorbed or retained by a green roof and by a roof without vegetation. They might discuss what the differences measured between the covered and uncovered roofs show in terms of the Sedum plants' ability to retain or delay water. They can compare their data on evaporation and water absorption, taken from the real plant measurements, to the programmed simulation. Then they can discuss whether their programming models are realistic, or whether adjustments should be made. In accordance with their level of education, they might add other factors that influence the plants and the simulated model.

CONCLUSION

After carrying out both steps of programming and monitoring on live plants, the students will understand the effect of a green roof and the plants' ability to absorb water and delay run-off. They will find the animation fun and it will be inspiring for them to learn the programming code needed for explaining a physical model.

Share your work with others

To share achievements, the students can present their results in many ways: in articles, oral presentations, films, podcasts or posters. Constructing a scientific poster requires a layout that is pleasing to look at, easy to grasp without further introduction, and factual. It is not an easy job to tell others what was achieved and learnt with this method. Photos are useful in order to visualise your efforts. All of the methods mentioned can also serve as background material for a QR – quick response code. It's just a click and an app away on your Smartphone.

You can easily generate a QR code from the Internet – e.g. at qrcode.kaywa.com.

If you want to generate the code for a text you simply click "text" and "generate" – the bar code appears immediately. Remember to store the code. You can also click URL and thus get easy access to a Webpage containing the information you want to share with others.

Additional suggestions: www.science-on-stage.de

Ederlinda Viñuales Gavín · Cristina Viñas Viñuales

B

Length of a Day

INTRODUCTION

In this teaching unit, we want students to measure or calculate:

- The time of sunrise and sunset on a given day,
- the length of that day, and
- the graphical representation of the heights of the sun on the horizon throughout the day. Students can also keep tabs with the data obtained for one day, then repeat the calculations for another day and compare the two.

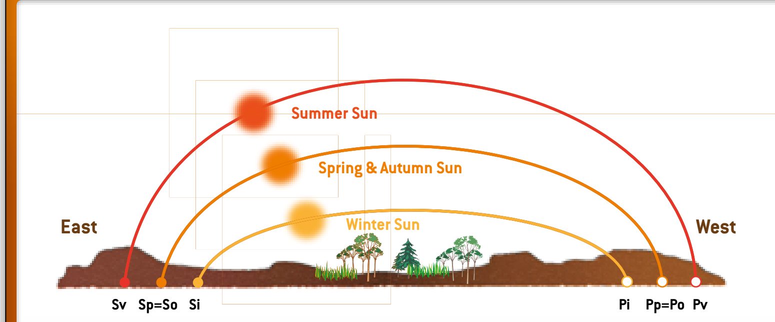
Students of this unit should be between 15 and 18 years old because they need prior knowledge of trigonometry and astronomy.

N.B.: For the purpose of analysing the length of days according to seasons, "seasons" are those of the Northern hemisphere.

Some notes on astronomy

The sun's daily path across the sky varies throughout the year. In the summer, the sun is at its highest point in the sky. In the winter it follows a lower path, which is why the days are longer in summer than in winter. In the spring and in autumn the sun describes intermediate paths, as shown in the next figure. ①

① Path of the sun on the first day of each season



Sv, Sp, So, Si dots indicate the sunrise in summer, spring, autumn, & winter.
Pv, Pp, Po,Pi dots indicate the setting sun in summer, spring, autumn & winter.

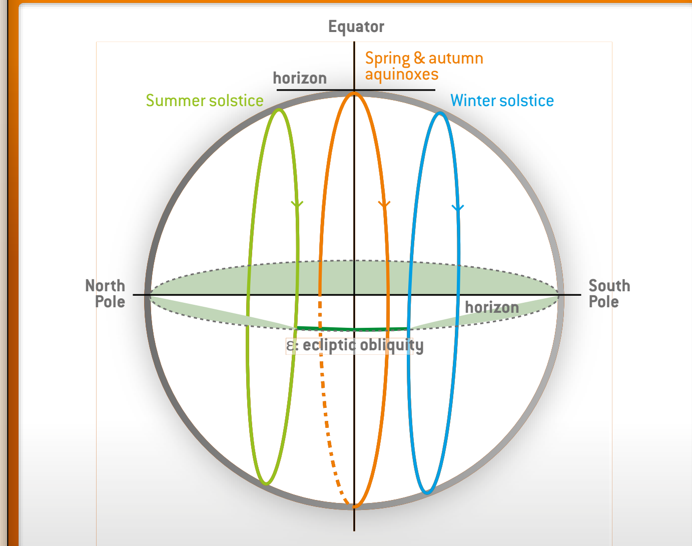
On the first day of spring, the sun crosses the celestial equator (the declination of the sun is 0). During subsequent days, the sun's apparent motion follows higher orbits until the first day of summer when it reaches the maximum (declination ε). The next day, the trajectory is lower in the sky and goes down until the first day of autumn when it returns to tour the equator (declination 0), continuing down to the first day of winter at the lowest point (declination -ε). The sun rises every day to get back to the first day of spring that runs along the equator, thus restarting the cycle of a new year.

Length of a day describes the moment from when the upper limb of the sun disc appears above the horizon during sunrise, to the moment when the upper limb disappears below the horizon during the sunset.

The length of day varies throughout the year and depends on the latitude. The inclination of the Earth's rotation axis causes the seasons to change and the position of sunrise and sunset to change every day. The maximum angular distance between two sunrises or two sunsets is the angle between two solstices. This angle changes with the latitude of the place. It is at its minimum along the equator (where it is equal to ecliptic obliquity ε). After that it increases according to the absolute value of the latitude, until it causes the midnight sun in the polar area. So, in an equatorial city (latitude $\phi = 0°$), the distance between two sunsets can be, at maximum 2ε (between June and December solstices), see ②. In any place along the equator, the length of day and night is always the same: 12 hours.

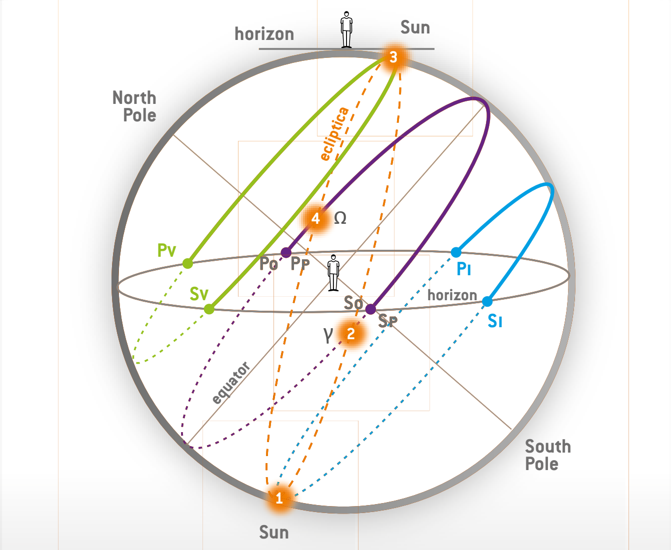
At the Pole the sun's path is parallel to the horizon (midnight sun) and it is not possible to consider the angular distance between two sunsets because we don't have sunset points. In places near the polar circle, the length of day (or night) can vary from one day to six months.

② The sun's path at latitude 0° (on the equator)



Our city Zaragoza has a latitude above 40° N. It is for this zone that we calculate the length of day and its variation for different times of year. In our region, day and night are of equal duration during two days of the year: the days of the equinoxes. From spring equinox to the autumnal equinox, days are longer than nights. Finally, from the autumnal equinox to the spring equinox, the length of the night exceeds length of the day. In ③ we present the path of the sun, the days of the solstices, and equinoxes for latitudes similar to ours.

③ The sun over our horizon



In the blue the winter solstice, in purple the equinoxes and in green the summer solstice

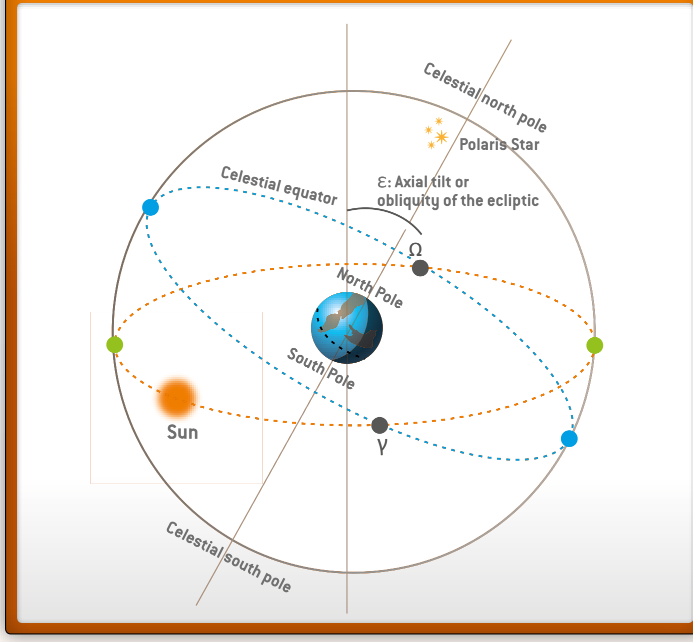
But, what are the ecliptic and the obliquity of the ecliptic?

The ecliptic is the plane of the Earth's orbit around the sun. In other words, it is the intersection of the celestial sphere with the plane containing the Earth's orbit around the sun (ecliptic plane).

As the axis of rotation of the Earth is not perpendicular to the ecliptic plane, the equatorial plane is not parallel to that ecliptic plane. An axis perpendicular to the ecliptic and the Earth's rotation axis creates an angle of about 23°26', and is called the obliquity of the ecliptic. It is represented by ε.

The intersections of the equatorial and ecliptic planes with the celestial sphere generate two maximum circles, known as the celestial equator and the ecliptic respectively. The line of intersection between these two planes at two opposite points leads to the equinoxes (see ④).

④ Ecliptic and equinoxes



The Vernal equinox (or point of Aries) occurs when the sun passes from south to north. The autumn equinox (or point of Libra), occurs when the sun passes from north to south. The obliquity of the ecliptic is not a fixed quantity but changes over time in a cycle of about 26,000 years. The slow and gradual change in the orientation of the axis of rotation of the Earth is due to the torque exerted by the tidal forces of the moon and sun on the Earth's equatorial protuberance. These forces tend to carry excess mass present in Equator to the plane of the ecliptic.

RESOURCES

For the first part: (introduction and presentation of the work) we used a Mac OS X computer, version: 10.4.11. and Word and Adobe Illustrator CS for figures.

For the development of the application we used Eclipse IDE with Java, on a Windows system.

To check the calculated values in the Java application, it would be desirable to have a Pin Hole camera or a stick, a string and a protractor, so that students can perform the measurements themselves, using simple tools.

CORE

The Java program (see www.science-on-stage.de) for calculating the length of day is divided into two sections. The left-hand side is for introducing some parameters such as the date, the latitude and longitude of a place. This left-hand side will also show the numerical results for the time of sunset, sunrise and the value of the length. The right-hand side will show the sun's highest point of the day for the location requested. The line starts at the sunrise date and time, evolves into the higher value, and decreases until the time of sunset.

There are also three buttons ‚Calculate', ‚Clear Values' and ‚Clear Sun Paths' that will allow you to reset given values, to start the calculation, and to clean the sun's path graph.

Calculations registered by the program can be found on the teaching-unit version on the Internet. They can also be used to calculate the length manually. However, as this is a complex process, we advise you to use the Java program to obtain different results and to complete the analysis.

Let us check, for example, how, in the same place, and over a period of one year, the heights evolve, when entering different values. The next figure shows the results. ⑤

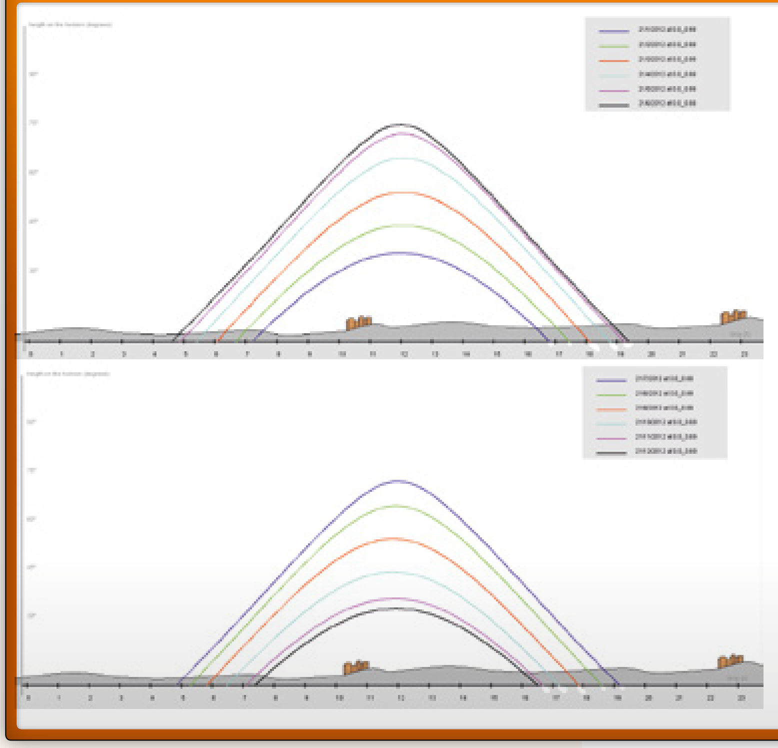
In the last figure we see how the height of the sun increases until the month of June and also how the length of day increases by having earlier hours of sunrise and later hours of sunset. However, from July to December the height starts to decrease, influencing both the length of the day and the time of sunrise and sunset.

Another interesting thing to check is how the height of the sun differs for different locations on the same day. For example, for 21st June 2012, see the difference between 40° North and 40° South of the equator. It is interesting to see that the time of sunset and sunrise is more or less the same but the height can vary by more than 60° between the equator and the North Pole.

Varying only the longitude but maintaining the date and the latitude could generate another analysis. The result should be that the length of day and the height reached are the same but the times of sunrise and sunset time differ from the longitude time we entered.

It is also interesting to see that a day can last 12 hours during the equinoxes (around 21st March and 21st September). The maximum length takes place during the summer solstice (around 21st June) and the minimum length occurs during the winter solstice (around 21st December).

⑤ **Comparison of the sun path of the same location in each month**



As a final proposal for students, it could be interesting to verify some of the results obtained by the Java program by creating their own simple device. For example, using a Pin Hole camera, they can reproduce the variation of the sun's height throughout a day.

Using a simple stick, students can also calculate the angle formed by sunbeams and the horizon. This angle is the angular altitude (height) of the sun at this moment. Students can check the results for different times of the day and find out that the values measured with this simple device are similar to the values they obtained with the Java program.

Another way for students to make these calculations could be to mark the points on the ground where the shadows of the top of the stick are found throughout a day.

CONCLUSION

The Java application that we developed works for any day of the year and any terrestrial latitude. But while using the program, students may come up with strange results. For certain latitudes, the sun does not rise and set on some days, so you cannot measure the length of day. The program then issues a red text, warning us, that we are in

a place where people can enjoy the midnight sun in the summer. In contrast, some winter days are dark 24 hours.

The program can calculate the length of day for different dates and save the graphical representation for each of them. That way, we can compare the change in the time of sunrise and sunset, depending on the season, and as result find out the length of day.

As a special project for students, it could be interesting to assign calculations for different latitudes to different groups of three or four students each. Depending on the number of students, they can have designated latitude zones covering 15 or 20 degrees, for both the northern and southern hemisphere. Using their calculations, each group can prepare a graph in a PowerPoint presentation to show to fellow students and to discuss the results obtained within the different groups.

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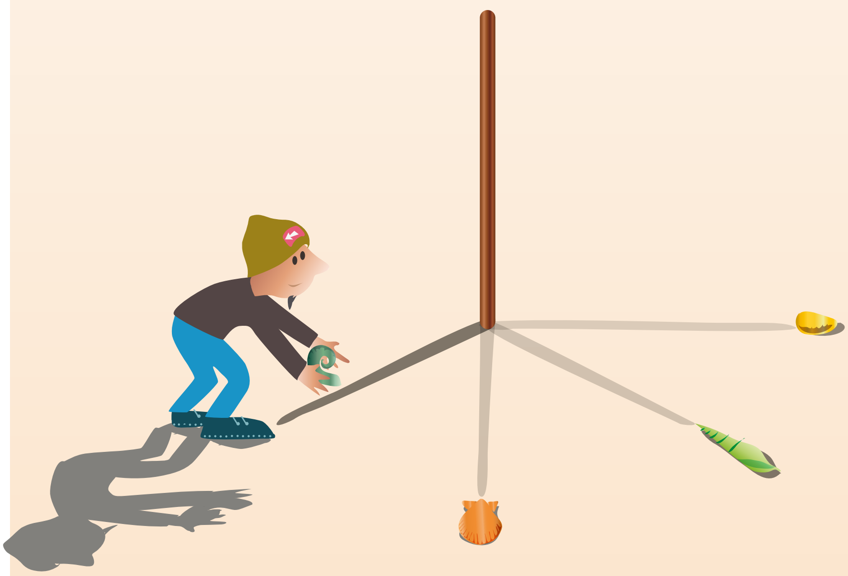


Ederlinda Viñuales Gavín · Marco Nicolini

B

Sun Exposition & Home Price

INTRODUCTION

Why do apartments in the same building have different prices? Why is a flat on an upper floor more expensive than one on a lower floor? We all know that this has got something to do with light and the luminosity of rooms. This teaching unit encourages students to conduct a field study and collect data on the surface area of apartments and windows, orientation and level of the floors as well as the prices of apartments depending on their orientation and floor level. Also, this teaching unit encourages students to examine the relationship between the varying real-estate prices, the economy, and related concepts of astronomy and earth sciences.

N.B.: In this text, the analysis of the sun exposition and direction refers to the sun in the Northern hemisphere.

Keywords

Prerequisites: sun daily path, latitude, elementary concept in statistics.

Interdisciplinary: This activity requires concepts of and involves topics in Astronomy, Geography, elementary Maths, construction formulas and Social Science. It requires fieldwork for collecting data, with the goal of familiarising students with their immediate social and geographical environment.

This teaching unit is recommended for students aged 15–17. It should be suitable for school curricula across Europe beginning with the last year of secondary school. The unit is perfect for international cooperation, as it allows data comparisons between cities of different countries. The unit can suggest statistics that evaluate and stress differences and analogies between countries, while relating them to latitude, population, prosperity, or other parameters. In the example provided here, three out of four cities share approximately the same latitude.

RESOURCES

All the activities are created for the purpose of data processing and analysis using a PC or a Mac. Spread sheets give an overview of price comparisons, especially if data from different regions or countries is being evaluated. We prepared a Java program for the astronomy part of the teaching unit. The program suggests helpful hints about sun radiance and latitude and encourages students to familiarise themselves with concepts such as energy, energy absorption, and radiance flux.

The student's guide and the Java application can be found at www.science-on-stage.de.

Programming: Students are encouraged to improve and develop further features in the Java program. So far, it calculates the average daily energy that reaches an apartment room and collects the data.

The Java program's preliminary activity is to collect data on the total amount of surface area covered for an apartment with south exposure, and on the latitude of that site. The Java program should help visualise the direction the sun's rays take against the backdrop of a generic profile of a south-facing window at the time of the equinox. This process will give you an idea of how important sun energy and latitude are, and it will calculate the daily amount of energy entering the apartment through the southern windows. At the same time, it keeps track of that part of sun's energy radiation per square meter that actually reaches the earth after atmospheric absorption.

We consider the Java program a key activity for this teaching unit.

CORE

Students are well-able to understand that light availability could be a good reason for paying more or less for a house or apartment. For instance, they easily observe that sunlight does not reach a first floor in the same way as it reaches an eighth floor. There could be buildings on the opposite side casting shadows on the lower part of "our" façade. As a result, the lower floors receive less light whereas the upper floors receive direct sunbeams.

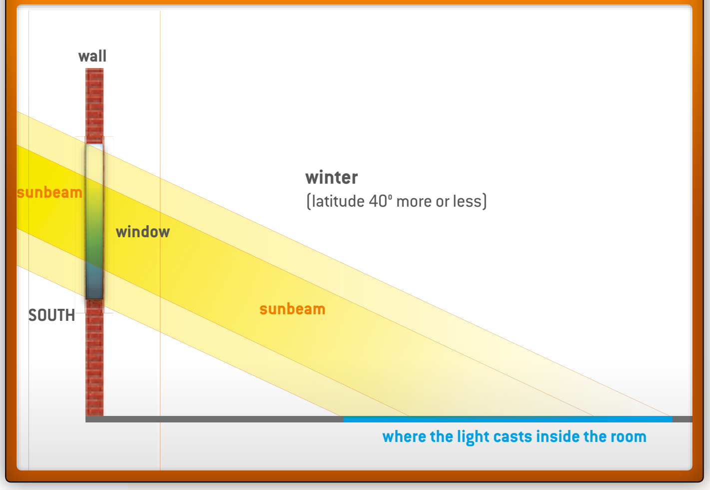
The same applies to orientation. A good orientation allows you to benefit from sunlight and heat.

We can observe how sunbeams enter through windows inside an apartment depending on the latter's orientation and the time of year.

In wintertime, at the south side of the building, the sunbeams shine through the window and fill a whole room. We have a warm and luminous hall. ①

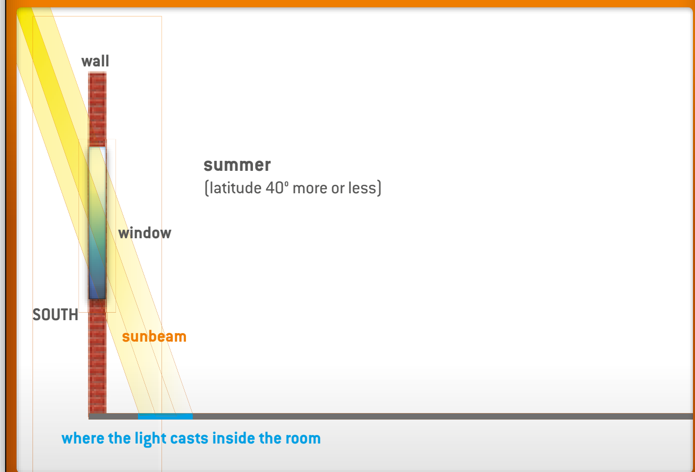
During the summer, sunbeams are cast on a wall. Light doesn't enter the room with too much intensity. The room is less warm than the west side, for instance. ②

① Sunbeams in winter



In these two pictures (①, ②), in which the wall faces toward south, we drew the inclination angles of the sunbeams at noontime. At this time, the sun reaches the maximum latitude on the horizon of a solstice day (December 21st, the winter solstice and June 21st, the summer solstice in the Northern hemisphere).

② Sunbeams in summer



Let us consider here, the behaviour of the sunbeams when the wall is facing east and west. In doing so, we will be in a position to compare the advantages and disadvantages of different orientations and draw the relevant conclusions.

When the wall faces east, orientation is also quite good because sunbeams enter the room during the early hours of the morning.

The winter is very pleasant because the sun warms the entire room and floods it with light. In the summer, the sunbeams work in a similar way and, although the sun heats more intensely than in the winter during the same hours, it is higher up on the horizon and the sunbeams enter only part of the room. An apartment's orientation toward the East is probably the second best one, compared to an apartment with a south-facing orientation.

If the wall faces west, the conditions of heat and light will change.

In wintertime the sunset is very early and the room only receives the last sunbeams of the day. They hardly heat the room. On the contrary, in summertime the apartment is already very hot when sunbeams begin to enter the room, due to the external temperature.

Input

Input data for the Java program is:

- The constant solar radiation reaching the earth: It can be considered a constant value of about 200W/m^2 but we decided to make it a variable parameter to be adjusted for different weather and climate conditions;
- The latitude;
- The total surface area of south-facing windows.

Analysis

We can assume that the solar radiation reaching the earth's surface in terms of energy per time unit per square meter is approximately 200W/m^2 (see also home.iprimus.com.au/nielsens/solrad.html).

We calculate the sun's average noon-time altitude on the horizon during a period of one year from its altitudes at equinoxes. This angle is the complementary angle of the latitude. The latitude angle is also equal to the angle that the external apartment walls and windows (perpendicular to the horizon) form with the sunlight coming parallel to the earth's surface. We can consider the amount of energy entering the apartment per time unit as the flux of the solar energy penetrating the surface area of the window. That can be defined as $F=R*S*\sin(\lambda)$, with λ being the latitude of the apartment site. We then average this radiation for the apartment's orientation, assuming it hits the windows' total surface area for 6 hours per day.

That means we have to multiply F by 6 hours (be careful to convert hours into seconds) and by the total surface area of external walls with windows facing south, to get the amount of energy per day. See Picture ③.

Output

The numeric output must be the average energy received through the south-facing windows of the apartment's south-facing walls on an average day.

The program should also draw:

- The window's profile, with the direction of sunrays on equinox, shows the angle between sunrays and window's surface, corresponding to the latitude
- The geographical latitude of the site on equinox

[These two graphics are currently under development. A constant graphic is shown. Nevertheless, students can figure out the Java code and adjust it to their latitude.]

CONCLUSION

In a pilot project of this activity, different groups of students, in every country, visited apartments and shops asking for information about the district, inhabitable area, prices, orientation, following the "Guide to students" at www.science-on-stage.de. They were interested in diverse information, so they wanted to know the prices for different city districts.

It could be interesting to write a short commentary about the difficulties students are faced with when it comes to obtaining information about apartment prices. Many times, salespersons were aware that students did not want to buy the apartment. The seller (in the pilot project) did not meet with our students, which is one of the reasons why the data might not always be accurate.

This activity is most valuable when performed as part of an international cooperation project, or at least when it involves different cities and regions in the same country. That way, students are able to compare totally different conditions in terms of climate, latitude, orography, and economical and geographical situations.

Interesting data can be obtained with respect to latitude, social situation, the country's flats policy, effective influence and activity of the sun during daytime.

The input parameter "Radiance from the Sun" can be used to "modulate" the geographical, orographical and meteorological conditions. Starting from the averaged value of 200 W/sqm, the solar radiation can be increased for lower latitudes, favourable climate conditions, annual meteorological situation, and average cloud cover.

Home activity

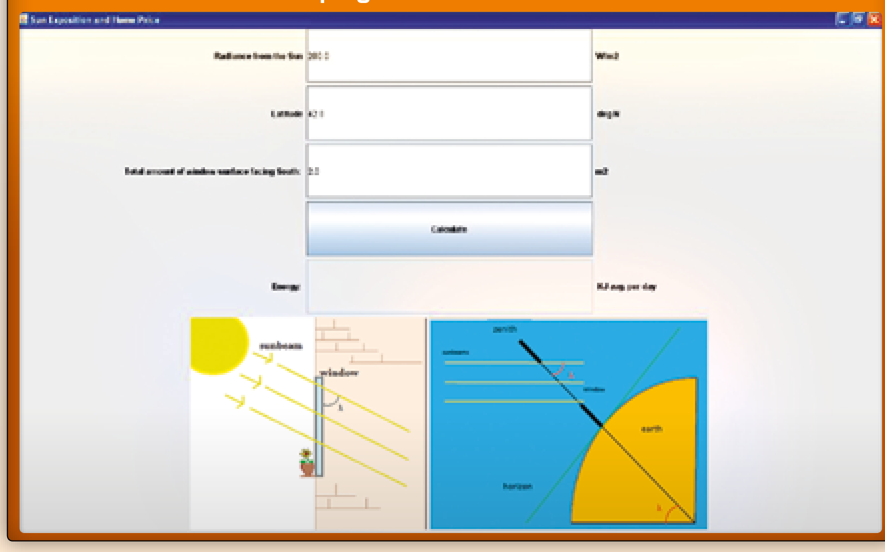
Data collection, forms completion, data exchange with international partner schools, data input into spreadsheet and/or Java program, graphics, comments.

Students could also perform some programming, at least for spread sheets.

Students may also want to figure out the reasons why the graphics' output looks the way it does, while trying to relate it to geographical, social, and economical causes.

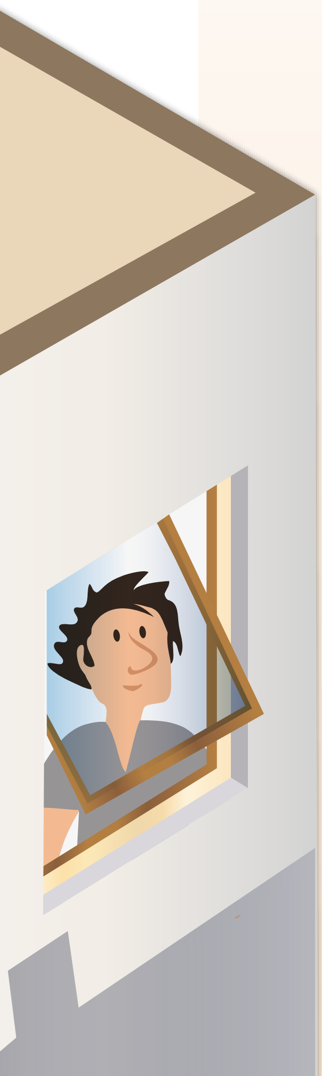
An interesting outcome could be the publication of the results in local newspapers of all participating cities, so the schools may even initiate a kind of city-partnership activity.

③ Screenshot of the Java program



Yet another worthwhile angle might be that of introducing the windows' inclination as a new input parameter: By changing the windows' inclination to the horizon, the radiance flux through south-facing windows can be increased and reach its maximum value. Velux-style windows are an example of how one can increase this energy from the sun, approximating a 90 degree angle λ. Introducing this new parameter allows new considerations and discussions on optimising home-energy income.

Due to international developments, these activities can create an effective and easy way for potential participant schools from different countries to communicate with each other. Among the available platforms, the wiki exchange system is a valuable resource and efficient solution for sharing contents and collaborating among schools. With different access points for teachers and students, these exchange and cooperation platforms are perfect for any school environment and allow students to develop shared activities globally.



From Bicycle to Space

In our attempt to capture students' interest, we usually try two extremes. We either ask ourselves: "Is there something in their everyday life that might get them involved?" Or, we try the opposite: "Can we find something so remote, so extreme, yet so fascinating, that they really want to know?"

"From Bicycle to Space" entails four teaching units, starting with the everyday exercise of riding a bike to the fascination with outer space. The use of ICT is a regular occurrence in science and using computers best solves the classical mechanical problems. However, ICT is not usually found in science classrooms of European secondary schools. By way of the following units, we would like these classes to get a little taste of information and communications technology (ICT).

The teaching unit "Science in Sports" explains how students can solve problems in classical mechanics by analysing videos of bicycle rides with the free software tool "Tracker".

The authors of the next unit dive deeper into the subject of mechanics: With the help of self-written software and freeware, students tackle the harmonic motion of "Swinging Bodies".

Looking at the firmament, students find out about the "Phases of the Moon" and enter their results into a self-written Java application. The students learn how to calculate moon phases, and visualise them in a computer simulation.

Finally we want to entice students by incorporating their dreams. In the wonderful teaching unit called "Space Travel", two different self-written computer programs explain the details of travelling between planets of our solar system. For the programming, the authors received help within their local community in Romania and in Greece.

"From Bicycle to Space" is a solid collection of ideas contributed by European science teachers, who got involved with programming. You took the first step! Congratulations!

DR. JÖRG GUTSCHANK
Leibniz Gymnasium | Dortmund International School
Main coordinator
Board member Science on Stage Germany

Martin Soegaard · Damjan Štrus

C

Science in Sports

INTRODUCTION

This teaching unit goes well with information and communications technology (ICT) and classical mechanics. Almost everything in terms of theories in classical mechanics is suitable for usage of ICT. The software Tracker (see annex) is very useful for studies of position and its derivatives (velocity, speed and acceleration), forces (e.g. Newton's 2nd law), and work and energy (gravity, Hooke's law, potential and kinetic energy). Students can easily do the analysis as early as age 13. The analytical complexity of the experiments can increase with students' age.

Working with video analysis is ideal for hands-on, inquiry-based learning and working with the Scientific Method. The Scientific Method is a great way to make students think about the experiment before conducting it. Not only will they reproduce results, they will also be involved in the experiment. ①

RESOURCES

You need a computer with the free video analysis and modelling tool Tracker installed, and any type of digital camera or mobile phone that can record video. If your school already has another video analysis software, you may prefer to use that instead. In all cases, the first step must be to record physical phenomena with a video camera. Then the recording is imported into the video-analysis software, which allows us to process images and analyse relations between physical quantities.

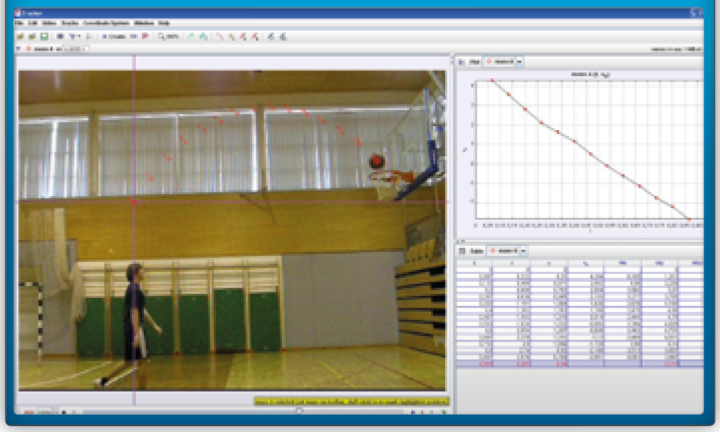
CORE

Input

For our teaching unit, students are required to record a specific movement of the sport they are analysing, e.g. a moving bicycle, a runner, a basketball thrown into the basket, etc. Then they analyse the physical laws of the chosen type of motion. When all is completed, they may present their project to other fellow students, using presentation tools, e.g. Prezi, PowerPoint, Glogster, or some other software suitable for presenting a project. The presentation could lead to a subsequent discussion of the results.

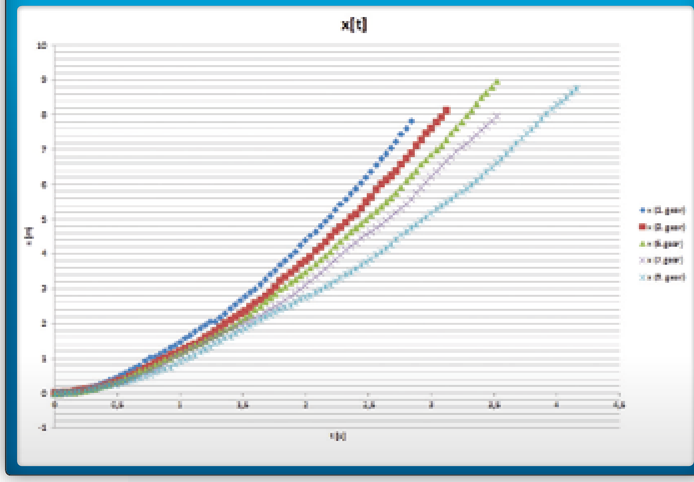
In this teaching unit, we analysed the movement of a bicycle. We conducted the experiment at a school in Slovenia and Denmark, respectively. Afterwards, students from both countries compared their results.

① Analysis of a flying basketball with Tracker



- Students record a few videos. The person rides the bicycle on a horizontal surface for 10 metres (the camera must not move during the experiment). In the first video, the person rides the bicycle at maximum power in first gear. Then the experiment is repeated with a second video in the third gear, etc. If the bicycle has many gears, the latter should be divided into multiple intervals (e.g. five).
- Then students will measure the length of the bicycle to establish an average length of bicycles for their analysing videos.
- They use Tracker to make a Table using time (t), distance (x), velocity (v) and acceleration (a) for each video.
- Tracker cannot compare graphs from several videos, so all data must be transferred to an OpenOffice, LibreOffice, Excel, or other spread sheet. The main idea is that students draw just one graph in which they compare the velocity v(t) of the bike in all videos. There should be another graph to compare the acceleration a(t).

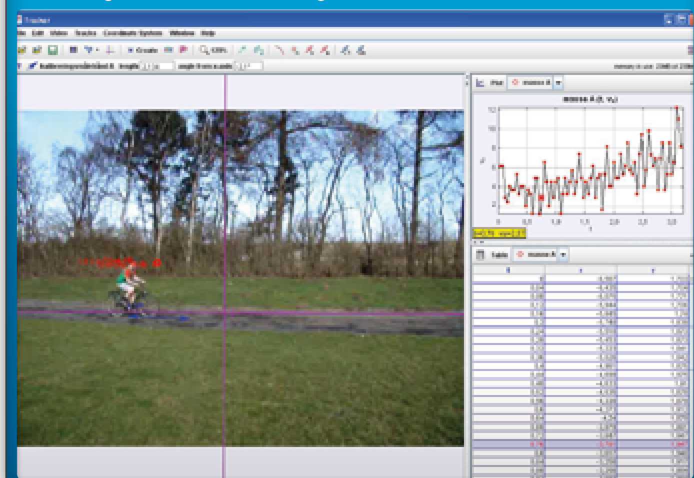
② Comparison of the velocity of the bike in different videos



- Finally, the students can analyse graphs and make a physical conclusion. If they set up a hypothesis at the beginning, using the Scientific Method, they can compare the outcome with their hypothesis. This way, students can see if the hypothesis was correct, partially correct, or wrong. Having students reflect on the experiment once more, will enable them to think about it long after its completion.

The bicycle example, and other examples mentioned here, are well-suited for independent homework projects which are presented in the classroom. The examples are also suited for class experiments, especially when you want to include ICT in your teaching. Students have at least two options: They can record a specific movement from the sport they have chosen, e.g. a moving bicycle, a runner, a basketball thrown into the basket, etc., or they can use pre-produced sports clips from online-video communities such as YouTube or vimeo. The chosen clip must contain some data (measurable data such as the length of the bicycle, mass of the observed body, as shown in the pictures, etc.).

③ Analysis of bike velocity with Tracker



All this information can be entered in the notes section of Tracker, located on the extreme right side of the main command-order line. You'll find them displayed when you launch the program. We are now presenting a few useful steps for using the Tracker video analysis with the help of our bicycle experiment:

- Import the first video you wish to analyse into the program;
- Determine the Start and End frames of the video to isolate the section you will be analysing (black arrows on the video slider);
- Calibrate your video with a known length, e.g. the length of the bicycle using Calibration stick. If you're working with a length in centimetres, you get the velocity in cm/s and the acceleration in cm/s². If you put the length in metres, the velocity is in m/s and the acceleration in m/s²;
- Determine the coordinate system that indicates to the software which section of the clip is considered to be a unit in the horizontal and vertical direction.

You'll find the buttons for all these settings in the main command-order line of the Tracker software.

The main part of the video analysis is where you denote the position of a moving bicycle as a function of time – we denoted a position for every single frame. You do that by clicking "Create Point Mass", then hold the CTRL-button down, and click the moving body on every single frame. Be careful to mark the same position on the bicycle in every frame. Thus, the software receives information about the bicycle position as a function of time.

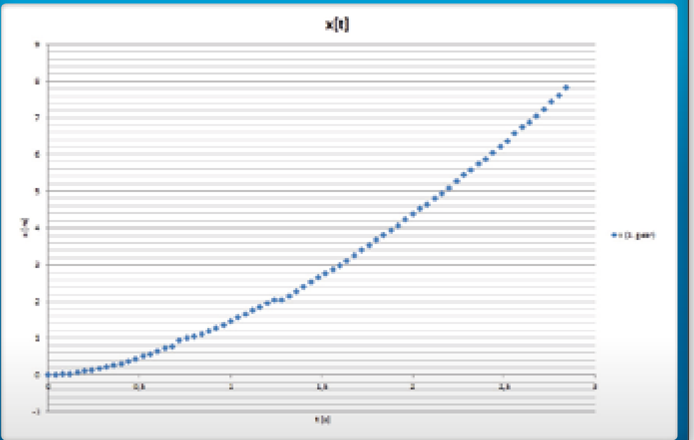
These are some of the things the students must know when they start using Tracker. If they want to know more, great support can be found in the Tracker help section. ③

Analysis

Based on the data, the software is ready to graphically demonstrate the time dependence of many quantities (position and speed in horizontal and vertical dimensions, actual velocity, acceleration and kinetic energy).

In our bicycle experiment we plotted the two graphs: x(t) and v(t). The picture shows the graph x(t).④

④ Graphical analysis of the velocity



From those two graphs, students can observe velocity and acceleration of the bicycle and compare acceleration in different gears.

For analysing relations between physical quantities, it is a good idea to enlarge windows with graphs (click the arrow on the right side of the main line of the graph window). Students can change the selected physical quantity by clicking the name of the quantity on the axis. The software opens a window in which you can choose another physical quantity. By clicking the same arrow on the right side, which is now facing down, students restore the previous view.

When teaching students aged 16–19, it is necessary to analyse graphs in greater depth. To do so, students must click the right mouse button on the graph they want to analyse. From the resulting pop-up window, they then select the option Analyse. Tracker opens a new window with a graph. For the bicycle experiment, we recommend that students find an adjustment curve for the graph x(t) and from the matching equation they can read out the acceleration. Then they do the same with the graph v(t) and read out the acceleration from the inclination of the graph, and compare the results.

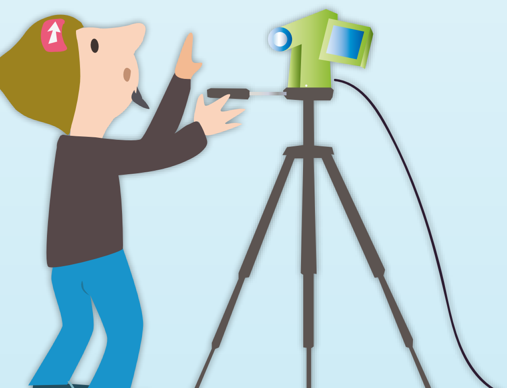
Output

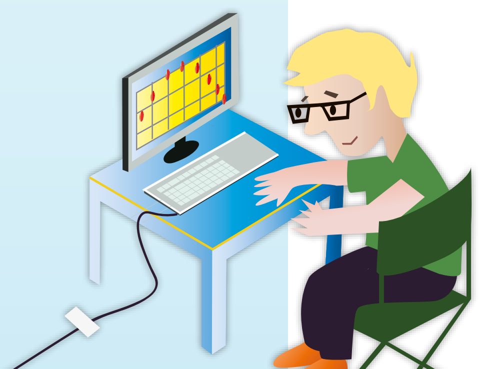
It is very educational to graphically observe these quantities: x(t), v(t), a(t) and $E_{kin}(t)$. Students first imagine what the graph would look like. Then they draw it, compare their results with classmates, and finally check all solutions together in Tracker.

Looking at the graph v(t), students then can discern the average acceleration of the bicycle by using the curve fitter in the Data Tool.

CONCLUSION

Students can set up hypotheses for the problems that they have to solve and for the varying ways in which different types of objects or persons react when they are part of an experiment. Video-analysis software such as Tracker can be very helpful in understanding many of the physical laws. It's a great tool for visualising the experiment the students are performing. During physical lectures students get the physical theory, for instance, they hear that all bodies (if they are solely affected by gravity) fall down to earth with the same acceleration, regardless of weight. They are able to write and use equations for path, speed and acceleration of movement with constant acceleration. They can draw graphs for path, speed and acceleration versus time. Additionally, this curriculum should be cross-linked with mathematics, so students are able to recognise the connection between $y=kx+n$ and $v=v_0+at$ etc. Tracker allows students to be very active: conducting and handling their own experiments, observing the relationships between quantities, and analysing experiments in detail. Finally they compare the theory with the results of their experiment and effectively are "learning by doing".

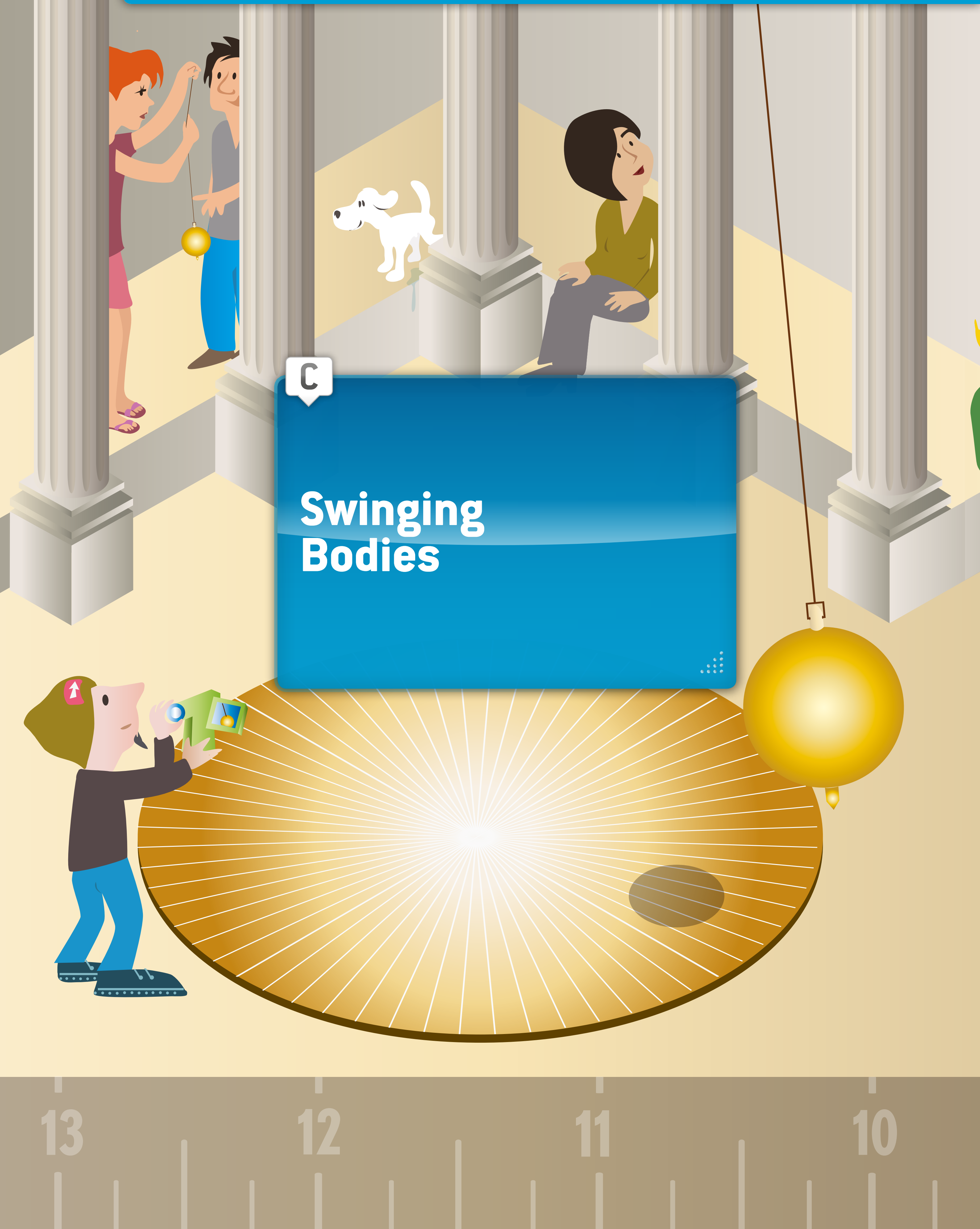




Anjuli Ahooja · Corina Toma · Damjan Štrus · Dionysis Konstantinou · Maria Dobkowska · Miroslaw Los
Students: Nandor Licker and Jagoda Bednarek

C

Swinging Bodies



INTRODUCTION

Oscillating objects are all around us. Each and every sound is produced by an oscillating source. Studying oscillation is not the easiest thing to do but we've broken it down to a simple concept of spring and pendulum motions.

The unit is recommended for students aged 14 to 16 years (level I), and for students aged 17 to 19 years (level II). The applied subjects are: physics, mathematics and information and communication technologies (ICT).

Level I

Students set up the spring or pendulum and make it oscillate. They observe the simple motion and record the oscillations with a video camera or mobile phone camera. Using Tracker or VirtualDub (see annex), they analyse the videos (frame by frame) to specify the motion character (displacement-time dependence). With the help of these videos and the graphical analysis, the students are able to determine frequency, time period, amplitude, and the spring constant or acceleration of gravity for a pendulum.

Level II

- **A:** These students take the same steps as younger students but they analyse the graph in greater detail. With the help of these videos and the graphical analysis, students can observe the phase shifts for displacement, and are able to find the following quantities: frequency, time period, amplitude, velocity, acceleration, and their dependence upon time. They also can verify the Law of Conservation of Mechanical Energy.
- **B:** The students have to add an accelerometer to the body of oscillation. They can register the acceleration values and applying this data, they can calculate period, velocity, amplitude, displacement, kinetic and potential energies. Then they plot graphs and may verify the parameters of the same motion using these two methods: differentiation (displacement → velocity → acceleration) and integration (acceleration → velocity → displacement).

RESOURCES

To work with this unit, students need: a digital video camera, a web cam or a mobile phone camera; a ruler, or other type of scale (to be placed in close proximity of the oscillating body and visible on the video); different kinds of springs, 3 to 4 objects of different weight, hanging from a spring; 3 to 4 pendulums of different lengths, a computer or a laptop; video-analysis software, e.g.: Tracker or VirtualDub; the Java application "Osc" available at www.science-on-stage.de.

CORE

The simplest mechanical oscillating systems consist of a body of mass m hanging from a spring or a pendulum (small oscillating angle). The inertia property of the mass m causes the system to overshoot the point of equilibrium. By applying Newton's second law to the oscillating body, one can obtain the equation of motion for the system.

The students have to revise the formulae for different physical quantities.

Level I

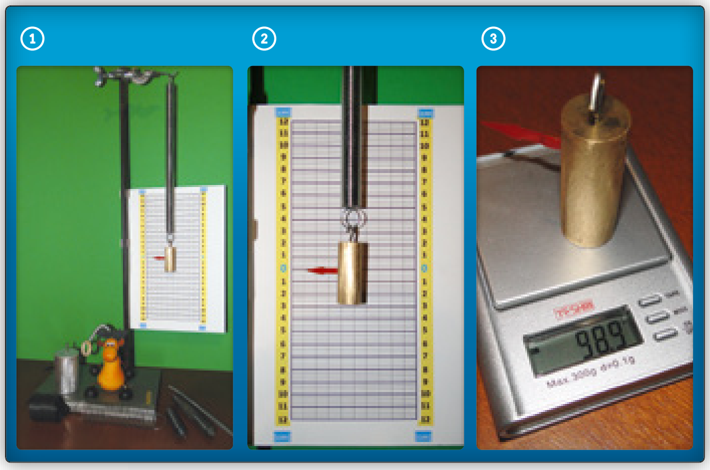
Level I students should revise the following physical quantities:

- The spring period: $T = 2\pi\sqrt{\frac{m}{k}}$, where m is the mass of the oscillating body
- The pendulum period $T = 2\pi\sqrt{\frac{\ell}{g}}$, where ℓ is the length of the pendulum and g is the gravitational acceleration

Level II

Level II students should revise the following physical quantities:

- Elastic force: $F = kx$, where k is the spring constant, x is the displacement of the oscillating body
- The time periods: for a spring $T = 2\pi\sqrt{\frac{m}{k}}$, where m is the mass of the oscillating body; for a pendulum $T = 2\pi\sqrt{\frac{\ell}{g}}$, where ℓ is the length of the pendulum and g is the gravitational acceleration
- Displacement of the oscillating body in simple harmonic motion: $x = A\sin(\omega + \phi)$, where A is the amplitude, ω is the angular frequency, and ϕ is the phase constant
- Displacement of the oscillating body in a damped oscillation: $x = Ae^{-(b/2m)t}\cos(\omega' t + \Phi)$ with $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$, where b is the viscous damping coefficient
- Velocity of the oscillating body $v = \omega A\cos(\omega t + \varphi)]$
- Acceleration of the oscillating body $a = -\omega^2 A\sin(\omega t + \varphi)$



- Total mechanical energy can be written as the sum of potential and kinetic energy:

for a spring $E_m = E_p + E_k = \frac{ky^2}{2} + \frac{mv^2}{2}$

for a pendulum $E_m = E_p + E_k = mg\Delta h + \frac{mv^2}{2}$

Experiment for Level I and II

- Set up the spring with a body of mass hanging from the bottom of the spring / set up the pendulum with a body of mass hanging from the bottom; place the ruler in the proper position to measure the displacement ① ②
- Record the mass (spring experiment)/record the length (pendulum experiment) ③
- Set up the computer webcam facing the spring/pendulum, so that it is able to capture the whole set
- Drop the body of mass from the original position and let it oscillate towards its mean position
- Save the video
- Measure the time period with a chronometer, or read it from the recorded movie
- Add an accelerometer to the body of oscillation and save the data (only level II)
- By changing selected parameters, find out how they affect the oscillation quantities

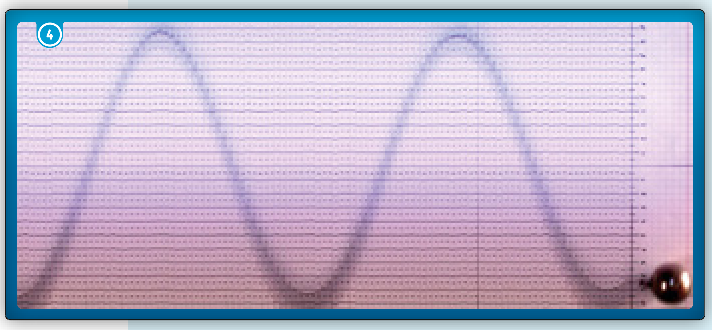
Analysis

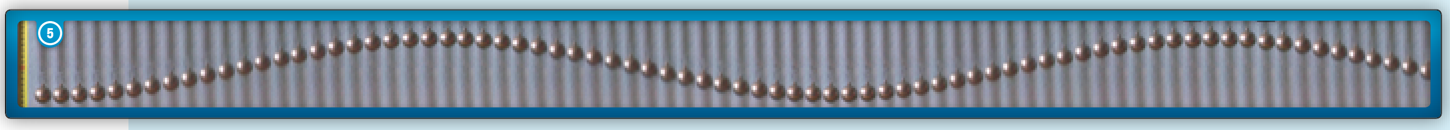
1. To start working with Tracker software, the students have to import the video clip and choose parts to be analysed.

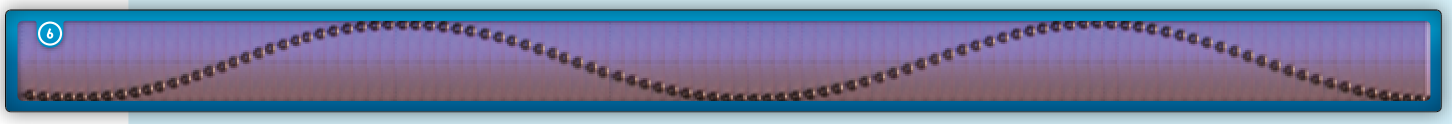
The program processes information about the position of the observed body as a function of time. Based on this data, the program plots graphs with the time dependence of different quantities: position in the horizontal and vertical dimensions, speed in these two dimensions, actual velocity, acceleration, mechanical energy (kinetic and potential). If students want to observe and analyse their variations, the program also allows you to define some new physical quantities.

2. Working with Tracker or VirtualDub, students may observe the common character of displacement variations for both spring and pendulum oscillations. Figures 4-7 are the combination of time-lapse images made with VirtualDub software. Comparing these images, one recognises similar characteristics between pendulum and spring oscillations.

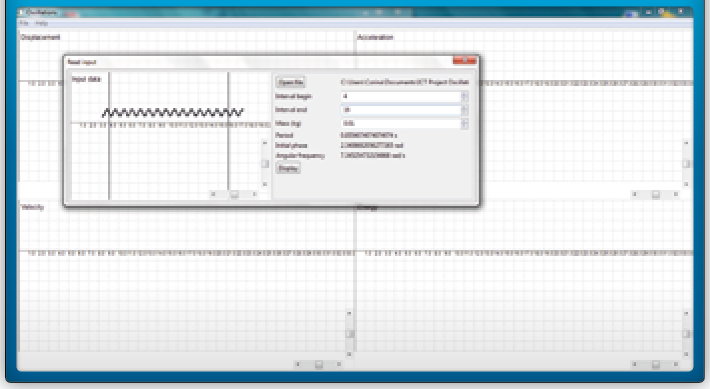
- Spring oscillations (summarised frame by frame) ⑤
- Pendulum oscillations (summarised frame by frame) ④
- Pendulum (summarised frame by frame) ⑥



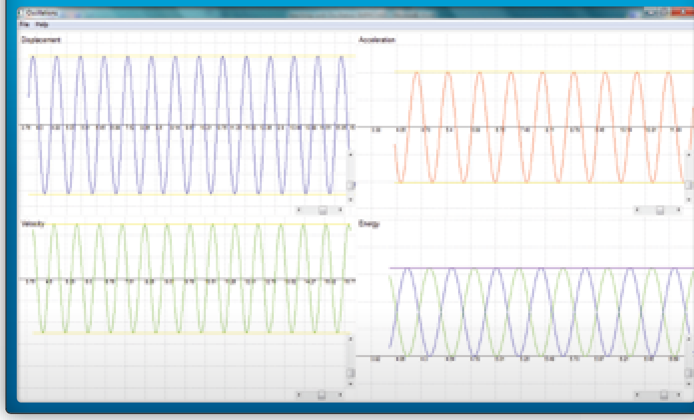




⑦ **Comparison of the experimental data and the simulation data**



⑧ **Diagram made with the software Osc**



3. An interesting way to study a simple harmonic motion of a spring/pendulum is to use an accelerometer, and to record the acceleration of the oscillating body. Then the students can process this data using the software "Osc" available at www.science-on-stage.de. The software provides four graphs with the time dependence of acceleration, velocity, displacement and total energy (kinetic and potential).

If students import the data, they have to draw the graph: a = f(t). From this graph, they can estimate the time period of the motion and calculate the angular frequency and displacement of the oscillating body. They then compare the experimental data with the data provided by the software. ⑦

Questions for Summarisation

Using Tracker, Virtual Dub or Osc students may work on the following main tasks:

- Observe the character of the oscillations (level I, II)
- Find out the characteristics for oscillations (I, II)
- Plot the graphs: T = f(m), if k is constant and T = f(k), if the mass is constant (level II for spring), and T = f(l) (level I, II for pendulum)
- Observe as the phase shifts between displacement and velocity and between displacement and acceleration (II)
- Verify the law of Conservation of Mechanical Energy – on the graph ⑧; the black curve represents the total energy, which equals the sum of the potential energy (blue curve) and the kinetic energy (green curve) (II)
- Check that the time period of the potential and kinetic energy variation is half the oscillation-time period (II)
- Verify the dependence T = f(m) for a spring with the constant k, if there are corresponding files with data for different masses, or the dependence T = f(k) for the same body of mass and different springs (II)
- Verify the dependence T = f(l) for a pendulum (I, II)

Using the same software "Osc" at www.science-on-stage.de, students can simulate a damped oscillation ⑨. They may choose the oscillation's parameters: frequency, amplitude, phase constant and also b/2m (where b is the viscous damping coefficient and m is the mass of the oscillating body) (II). The students may formulate their opinion about: displacement values at the moment when velocity or acceleration reach their maximum or the point of 0, the difference between the motion period and kinetic or potential energy periods, and, last but not least, the influence of friction on the parameters of the motion.

⑨ **Simulation of a damped oscillation with the software Osc**

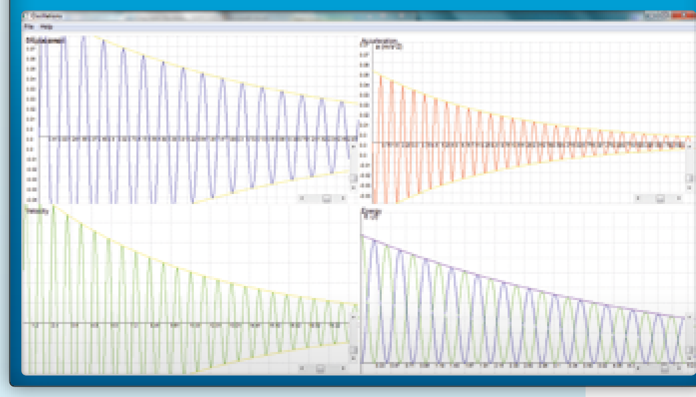


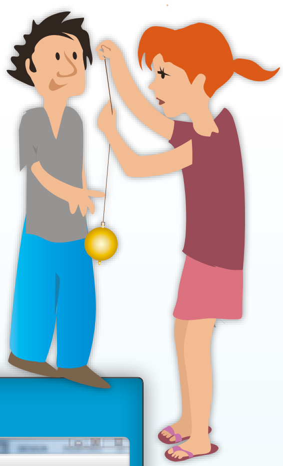
Figure ⑩ shows how to perform a simple set for testing the damped oscillations. Figure ⑪ is the result of analysis made with Tracker.

The students may formulate conclusions about:

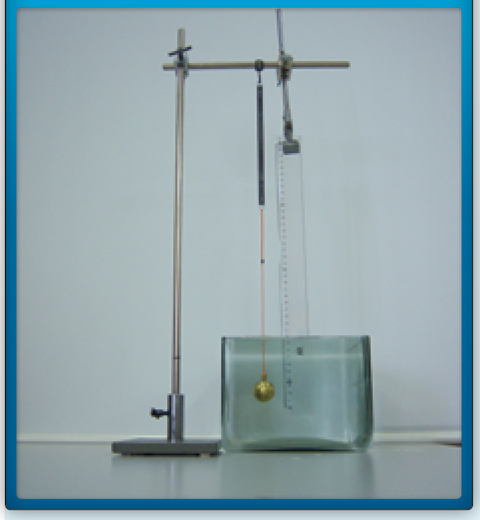
- The displacement values when velocity is maximum or zero
- The displacement values when acceleration is maximum or zero
- Why the period motion is two times the variation period of potential or kinetic energy
- The influence of friction on the parameters of the motion

CONCLUSION

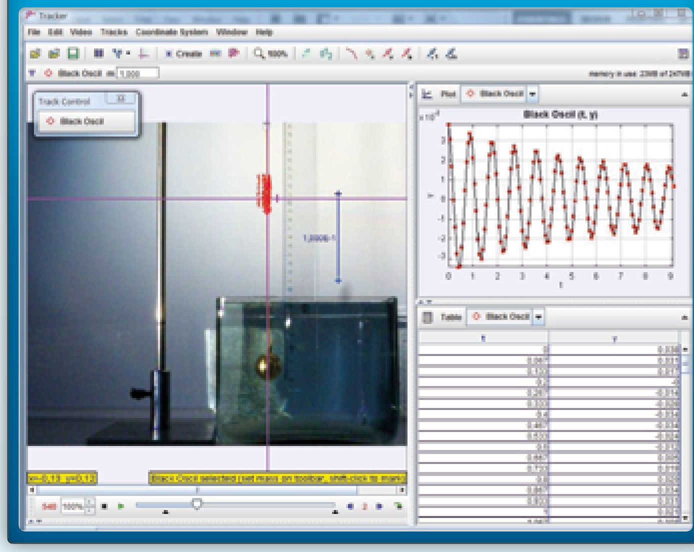
The simple motion of a spring is not quite so simple to study. By both doing experimental work and working with real data for the chosen software, students will easily understand the dependence between the different parameters of oscillatory motion, and develop their ICT skills. They will be able to apply the acquired knowledge to the study of other oscillatory motions.



⑩ Testing a damped oscillation with a simple set of materials



⑪ Result of the analysis with Tracker



Cristina Viñas Viñuales · Ederlinda Viñuales Gavín

C

Phases of the Moon

INTRODUCTION

Have you ever noticed that regardless of which place on Earth we are, we all see the same shape of moon on the same day? Have you ever noticed that the illuminated part of the moon changes sequentially and cyclically?

In this teaching unit, we'd like students to understand how the relative positions of the sun, earth and moon influence each phase of the moon, how to determine this phase for a given day, and how to calculate the percentage of its illuminated part.

This unit is recommended for students aged 14 to 16 years because some prior knowledge in trigonometry and astronomy is required.

Some notes on Astronomy

When we speak of the phase of the moon, we are referring to the lighted portion of the moon, as seen by an observer on Earth. This appearance changes cyclically, when the moon orbits the Earth, according to the relative positions of the earth, moon and sun to each other. One half of the lunar surface is always illuminated by the sun, but the portion of the illuminated hemisphere that is visible to an observer on Earth can vary from seeing the whole lunar disk illuminated (full moon) to not seeing it at all (new moon).

Early in time, it was recognised that the moon's shape depends upon its "age", that is, the number of days that have elapsed since the previous new moon. In ①, the inner circle shows the moon's orbit, assuming it is circular, the earth being at its centre. The sun's direction is indicated by the sunlight, and since the sun's distance is some 400 times the moon's, we can assume that the sun's direction, as seen from the moon, is always parallel to its geometric direction. The moon's illumination being provided by the sun, the day and night sides of the moon at different parts of its orbit will be as shown in ①.

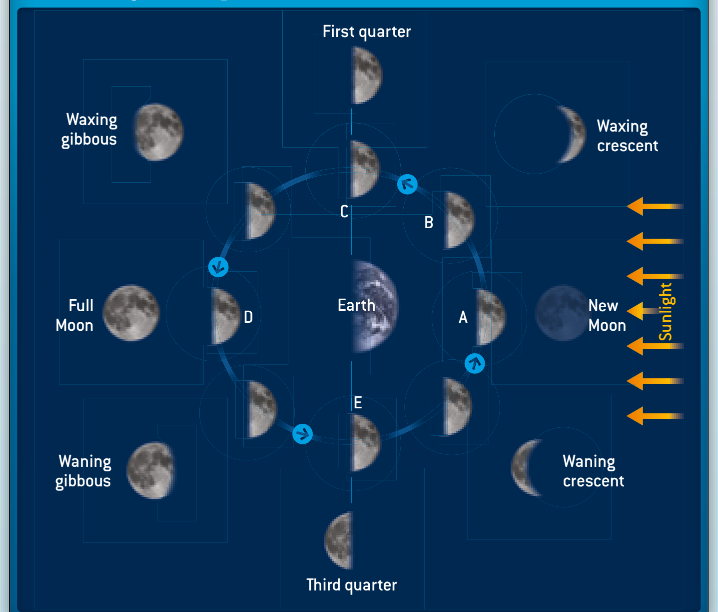
The outer circle of figures shows the appearance of the moon as seen from Earth, in other words: the phases of the moon. At point A the moon is new; at B we see a waxing crescent (waxing means growing and refers to the size of the illuminated part of the moon, which is increasing). First quarter occurs at C; between C and E, more than half the moon's illuminated face is visible, a condition known as gibbous. At D it is full moon; at E the position is called third quarter. Between E and A is a waning crescent (when the moon is said to be waning, we see a little less of the moon each day, until it completely disappears, at which point the moon is new).

We can now define the moon's synodic period, lunation or lunar month. Although the moon's orbit undergoes changes, an average value, defined to be the time interval between two successive new moons, has been determined for this period. This value, named Sc, is 29.53059 days.

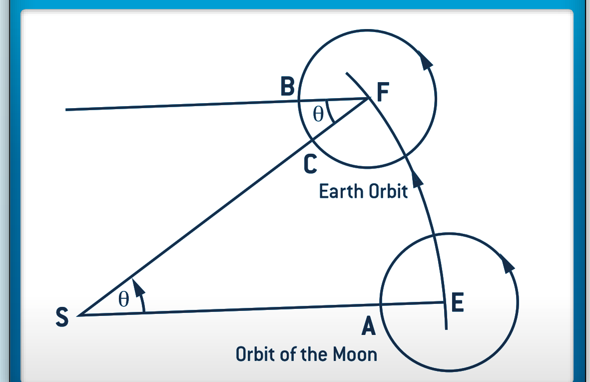
The moon's sidereal period or sidereal month is the time interval required by the moon to make one complete revolution around the Earth. With respect to the stellar background, this is the path from A to B in ②. Again, we can determine an average value. Here it is 27.32166 days.

The difference between these two periods of time is due to the fact that the moon has to travel a little further in its

① The day and night sides of the moon



② Relation of sun, moon and earth from a geometrical point of view



orbit to catch up with the sun which, from the geometric point of view, is also revolving around Earth (Earth has passed from E to F in ②, while the moon has to reach point C, and not point B, to be a new moon, as seen in point A). The three quantities, namely: the sidereal periods of revolution of the moon around the earth, the earth around the sun, and the moon's synodic period, must then be related to each other.

RESOURCES

First part: For the introduction and presentation of the work, we used a Mac OS X computer, version: 10.4.11. Applications: Word and Adobe Illustrator CS for figures.

For the development of the application, we used an Eclipse IDE (see annex) with Java 1.6 and the library Java3D. The application can be found at www.science-on-stage.de, where you can download it as well as download the source.

CORE

In this section, we are going to explain the steps needed to calculate the phase of the moon of a given day in the northern hemisphere. Students then could calculate the phase manually, or, if they prefer, use it as a base for programming an application like the Java version that we have prepared for ICT.

Input

The only data needed for calculating the phase of moon is the date for which the students want to know its phase. This date represents a day, a month and a year.

Analysis

1. First, the students start working with the given date (day, month, year). This date is transformed into Julian Days (JD is a system of time measurement used by the astronomy community. It presents the interval of time in days elapsed since the epoch 1900 January 12 a.m., because it is midnight at Greenwich on 31 December 1899). The hour is fixed at 12:00 a.m. So, given a {day, month, year} to calculate in Julian days, we need to solve the following simple equations:

$$a=\frac{(14-month)}{12}$$

$$y=year+4800-a$$

$$m=month+12*a-3$$

So, JD [day, month, year] of

$$JD[day, month, year]=day+\frac{(153\cdot m+2)}{5}+365\cdot y+\frac{y}{4}-\frac{y}{100}+\frac{y}{400}-32045$$

is the day chosen in Julian's Day format.

2. A reference date of a past new moon is also needed, for example 1st January of 1900. This date needs to be transformed into a Julian Day just like in the previous step.

Remember that if JD $[1,1,1900]_{Reference}$ is the reference date, it is not possible to calculate moon phases before that date.

3. The next step is to calculate the difference between the date we want and the reference date:

$$JD[x]_{Current}-JD[x]_{Reference}=D$$

This calculation allows you to find out how many days passed since this known new moon.

4. As we explained, Sc is the time interval between two successive new moons. With that, if we made an integer division D/Sc, the rest will be the days passed since the last new moon. Calling the rest A, A will be the age of the moon. So, Age of the moon = A = D modulus Sc

5. As Sc is 29.53059, and the rest of the division is zero, the phase of the moon will be new. Thus, the rest can take on values between 1 and 29, with 29 being the equivalent to zero or new moon.

Now it's easy to assign a number to each value of the rest of the phases. We do this in a counter-clockwise direction, see Figure 1. So, a value of 0 is equivalent to new moon, a value of 7.38 corresponds to the first quarter, 14.76 stands for a full moon and 22.15 represents the third quarter.

6. If, in addition to viewing the phase of the moon on our chosen day, we want to calculate the percentage of the illuminated part, we have to use the formula

$$Percentage=\frac{1}{2}\left(1-\cos\left(\frac{360}{S_c}\right)*A\right),$$

which gives us just that percentage. If P = 0, the phase is new moon, if P = 1, it is a full moon. But if P = ½, is it the first or third quarter?

Here we need to take some other aspects into consideration. Let's call A the age of the moon used on the previous formula, and η = 360*(A/Sc). The η is called the moon's elongation. See figure ②B. When the sun, the earth and the moon are aligned in the order cited $\eta = 180°$ and there is a full moon, and 29/2 days have passed since the last new moon, we can take a look at Figure ②B and make the following assumptions:

If $0 < A \leq 29/2 \rightarrow 0 < \eta \leq \pi$ then we have two cases:

- For $0 < \eta < \pi/2$ the moon is waxing crescent, the shadow is on the left and the illuminated part is less than half the lunar disk ③
- For $\pi/2 < \eta < \pi$ the moon is waxing gibbous, the shadow is on the left and the illuminated portion is greater than half the lunar disk ④

If $A = 29/2 \rightarrow \eta = \pi \rightarrow$ full moon.

If $A \geq 29/2 \rightarrow \pi < \eta \leq 2\pi$ then we have two cases:

- For $\pi < \eta < 3\pi/2$ the moon is waning gibbous, the shadow is on the right and the illuminated portion is greater than half the lunar disk ⑤.
- For $3\pi/2 < \eta < 2\pi$ the moon is waning crescent, the shadow is on the right and the illuminated part is less than half the lunar disk ⑥.

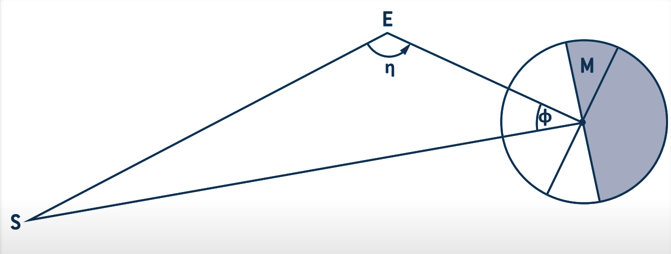
That said, we are able to specify: If $P = ½$, the moon is in first or third quarter. Similarly, we can deduce, for example: If a percentage value of 0.8 corresponds to the right or the left side of the lunar disk, then the phase is a waxing or waning crescent, respectively.

Output

Having completed the analysis, the students are able to know which phase corresponds to the given date and what percentage of the moon's surface is illuminated.

As part of the unit, a Java application is developed. Students and teachers could use it to better understand the influence of the relative positions of the sun, earth and moon to each other, and during certain phases of the moon, or they can verify their results.

②B The moon's elongation



In this application, there are three zones: an info panel of the current phase at the left side, an animation with the sun, earth and moon at the right side, and the text fields for entering the date at the bottom.

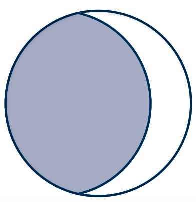
In the animation panel there are two buttons to see the animation, 'Play' and 'Stop'. Use these to control the positions of the moon, earth and sun. Depending on the position, the information panel on the left side will show you the current phase of the moon.

For calculating a certain phase for a date, students only have to enter the day, month and year in the bottom text fields and press 'Calculate'. The info panel and the animation will update their content showing information about the calculated moon phase.

If they want to calculate the phase manually, they only have to follow the previously explained steps, and verify their results with the application.

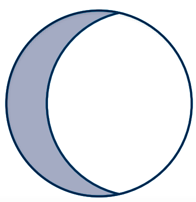
As said before, this program can calculate the phase of the moon for any day in the northern hemisphere. We encourage students to investigate how the inhabitants of the southern hemisphere see the moon on a given day. Do they see the same phase we do? How does the view of a phase differ (other than the new and full moon) from one hemisphere to another? Can you explain that differ-

③ Waxing crescent phase



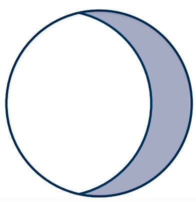
$0 < A < 29/2$ $0 < \eta < \pi/2$

④ Waxing gibbous phase



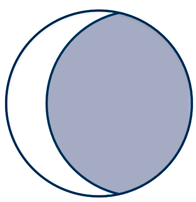
$0 < A < 29/2$ $\pi/2 < \eta < \pi$

⑤ Waning gibbous phase



$A > 29/2$ $\pi < \eta < 3\pi/2$

⑥ Waning crescent phase



$A > 29/2$ $3\pi/2 < \eta < 2\pi$

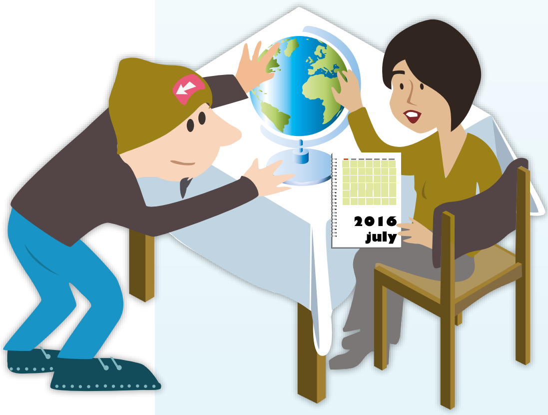
ence? And finally, we encourage students to make a program that allows them to visualise the phases in the southern hemisphere.

CONCLUSION

This unit presents a guided method to calculate the phase of the moon for a given date.

Teachers are advised to encourage their students to learn these basic concepts of astronomy as well as follow the simple steps for calculating and explaining moon phases.

Both teachers and students could also use the Java application to better understand the process, check their results, or just compare phases for consecutive days. The Java source code is also a good way to program these kinds of simulations.



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Dionysis Konstantinou · Corina Toma

Space Travel

INTRODUCTION

Imagine travelling from one planet to another. Why is it that we have to first travel in circles instead of taking the straight path? Before going on our trip, we must consider: the revolution velocity of our starting planet, the required spaceship velocity, and the optimum momentum for launching the spaceship (because if we miss it, we'll travel past the target planet, without even noticing it). Finally, we need to know the fuel economy of the trip (after all, we don't have gas stations in space). In this teaching unit, students study how a spaceship arrives on a circular orbit around a planet, and how it travels from one planet to another on a Hohmann transfer orbit. This unit is recommended for students aged 12 to 19 years. The applied subjects are: Physics, Mathematics, Informatics and Biology.

RESOURCES

The students need the following resources: computer Intel Dual Core with 2GB ram, 3D accelerated graphic card; Windows, Mac OSX, or Linux operating system; display resolution: min. 1024x768; installed software: Oracle Java JRE 1.6; license model: LGPL, Internet access.

For this teaching unit, we created two Java software applications: "Orbiting and Escaping" and "Solar System Travel" (see www.science-on-stage.de).

CORE

We will revise Newton's universal attraction law, circular motion quantities, Kepler's laws, and the potential and kinetic energy of a gravitational field.

Circular motion around a planet and escaping the planet's influence

The students should become familiar with the value of physical characteristics of circular motion of a satellite around a planet, or orbital motion of a planet. They should pay close attention to the velocity of circular trajectory around a planet, and the velocity required for escaping the gravitational field of this planet. They can find the formulae for these two velocities using the software "Orbiting and Escaping". They can verify the values with the software "Solar System Travel".

The application "Orbiting and Escaping" is based on the so-called "Newton's mountain model". Isaac Newton formulated a hypothetical experiment: If we climbed to the top of the highest mountain on Earth and from there, launched a projectile horizontally at appropriate velocity, during a time when Earth's atmosphere did not exist, we would have turned this projectile into an artificial satellite moving in circular orbit around Earth.

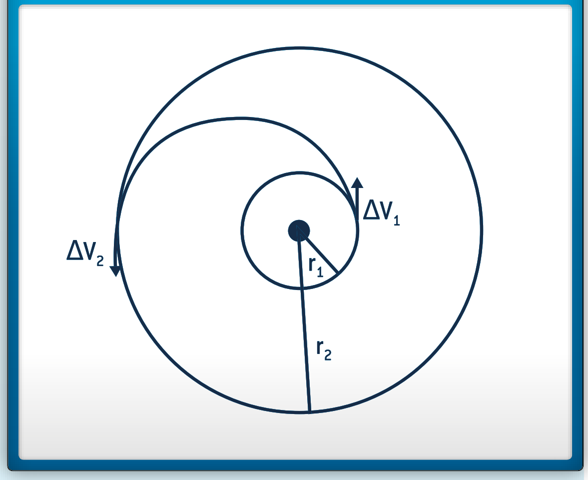
Travelling from one planet to the other on a Hohmann transfer orbit

Using the application "Solar System Travel", students have to make a choice and decide from which planet to which other planet they want to travel. By clicking on the Hohmann button they will be able to see the transfer ellipse between the planets. The ellipse shifts its position with the rotation of the start planet. It waits for the right time, when the planets' positions make travel possible. The application shows the spaceship travelling between the planets and calculates the time it needs to get to its destination.

The Hohmann transfer can be achieved with small thrusts initiated at the beginning and end of travel only. On the ellipse, the fuel consumption is set to minimum because this is where the changes of kinetic energy are smallest.

To travel from an orbit with the radius r_1 to another orbit with the radius r_2, we use an elliptical trajectory with the major axis = r_1+r_2, called Hohmann transfer orbit ①.

① Hohmann-Trajectory



The spaceship has to change its velocity twice, once at the beginning of the elliptical trajectory, and once at the end. This is done using the so-called velocity impulse delta-v (Δv). This change in velocity is a measure of the „effort" that is needed to change the trajectory when performing an orbital manoeuvre.

It is assumed that the spacecraft is moving on the initial circular orbit of the radius r_1 with velocity v_1, and on the final circular orbit of the radius r_2 with the velocity v_2. The gravitational force is equal to the centrifugal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$, where M is the sun's mass, m is the spacecraft's mass and G is the gravitational constant. The velocity v_1 and v_2 are given by:

$$v_1 = \sqrt{\frac{GM}{r_1}} \quad \text{and } v_2 = \sqrt{\frac{GM}{r_2}} .$$

The transfer consists of a velocity impulse Δv_1, which propels the spaceship into an elliptical transfer orbit, and another velocity impulse, Δv_2, which propels the spacecraft into the circular orbit with radius r_2 and the velocity v_2. The total energy of the spacecraft is the sum of kinetic and potential energy. It is equal to half the potential energy at the semi-major axis a:

$$\frac{mv^2}{2} - \frac{GMm}{r} = \frac{GMm}{2a}, \text{ where } a = \frac{r_1+r_2}{2} .$$

The solution for this equation yields the velocity at the initial point of the elliptical trajectory (perihelion) v'_1, and the velocity at the final point of the elliptical trajectory (aphelion) v'_2:

$$v'_1 = \sqrt{GM\left(\frac{2}{r_1} - \frac{2}{r_1+r_2}\right)} = v_1\sqrt{\frac{2r_2}{r_1+r_2}}$$

$$\text{and } v'_2 = \sqrt{GM\left(\frac{2}{r_2} - \frac{2}{r_1+r_2}\right)} = v_2\sqrt{\frac{2r_1}{r_1+r_2}} .$$

In this case, the changes in velocities are:

$$\Delta v_1 = v'_1 - v_1 = v_1\left(\sqrt{\frac{2r_2}{r_1+r_2}} - 1\right)$$

$$\text{and } \Delta v_2 = v_2 - v'_2 = v_2\left(1 - \sqrt{\frac{2r_1}{r_1+r_2}}\right).$$

Important

- If $\Delta v_i > 0$, the spacecraft burst is for acceleration. If $\Delta vi < 0$, the spacecraft burst is for deceleration.
- Kepler's third law yields the **transfer time** from the perihelion to aphelion:

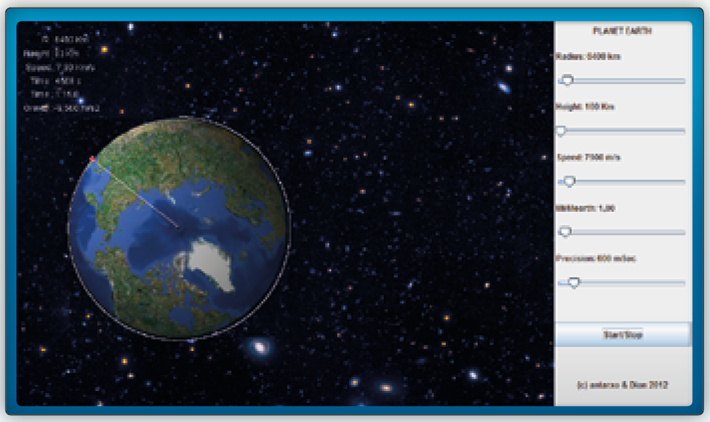
$$t = \pi\sqrt{\frac{(r_1+r_2)^3}{8GM}} .$$

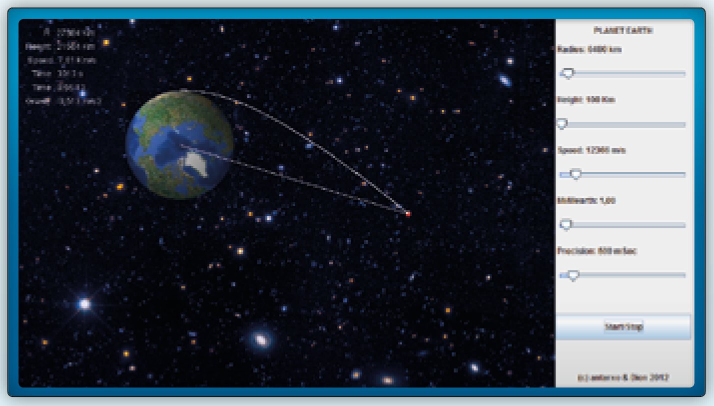
- **Waiting for the right moment**

The configuration of the two planets in their orbits is crucial. The destination planet and the spaceship must arrive in their respective orbits around the sun at the same point and simultaneously. This requirement for alignment gives rise to the concept of launch windows.

Student activities using the application "Orbiting and Escaping"

How to find the first and second cosmic velocities. The students can determine the circular velocity around the earth (1st cosmic velocity) and the escape velocity (the 2nd cosmic velocity) with the option "Earth" on the applet. They can see what happens when the initial velocity is greater or smaller than the 1st cosmic velocity.





How to define two formulae using this application. Using an essential experimental method, the students will determine the formulae that describe the circular velocity of a satellite orbit around a celestial body, and the escape velocity of this body. In doing so, they will discover the specific aspects of the Newtonian universal gravitation theory. At the basic level, when collecting and processing application data students will find each formula as proportionality. A more advanced approach allows them to define the coefficient of this proportionality changing it to equality.

With the option "Green Planet" (every other adjustment except $M_i/M_{Earth} = 1$ and radius = 6400 km, where M_i is the mass of the planet, expressed as the masses of Earth) the students may define the formula for the circular trajectory velocity. For this purpose, they choose a value for the planet's radius and enter the circular orbit velocity for different values of the planet's mass. When they reach a conclusion about the dependence between circular velocity and the planet's mass, they have to use these findings and transform them into a formula for proportionality. Repeating the same steps for a fixed value of the planet's mass and varying values for R (radius + height), students will arrive at a second proportionality.

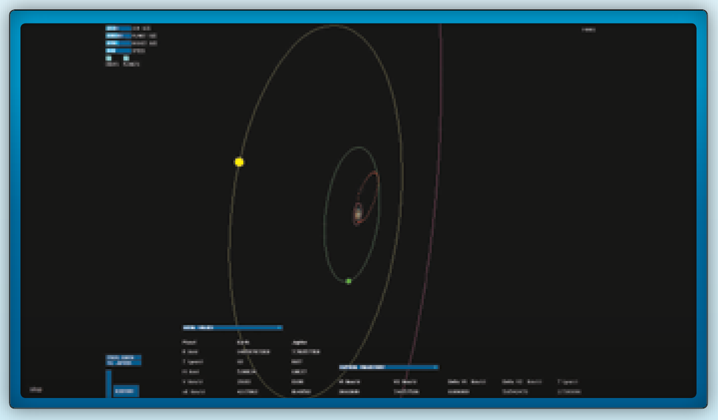
The process for finding the formula of the circular velocity around a planet will be completed when the students have changed the proportionality to equality. At first, they will merge the two proportionalities into one. Then they will draw a graph $v_2 = f(M_i/R)$ (where M_i is calculated in kg, with the $M_{Earth} = 6 \cdot 10^{24}$ kg). The slope of the graph gives the coefficient, which helps the students to find the equality.

Applying the same ideas, and following the same steps from the previous activity, the students can define the formula that describes the escape velocity, v_{escape}.

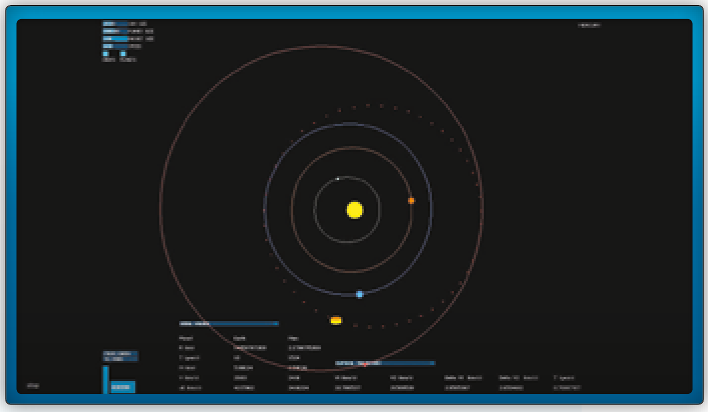
Student activities using the application "Solar System Travel"

Using the application, students can choose a journey between two planets. They can read the values for the initial velocities of every planet and for the Hohmann trajectory, and verify them with the newly created formulae from the first applet.

They can change the angle of the orbits using the SHIFT key, and zoom in and out with their mouse's SCROLL button.



The elliptical Hohmann trajectory (dotted) follows a rotational movement following the start planet of the spaceship. The students click the HOHMANN button and wait until the ellipse stops. At that moment the spacecraft begins its journey because the planets' configuration is favourable.



Studying orbital velocities and orbital periods for different planets

The students can conclude that the velocities of the planets are decreasing and the orbital periods are increasing with the increasing of the orbital radius. They can plot graphs for the planets' velocity and period evolution by increasing the orbital radius r, $v = f(r)$ and $T = f(r)$.

Comparison between different necessary velocity impulses (delta-v)

The students have to choose a Hohmann transfer orbit from Earth to Venus or Mercury. They can observe that $\Delta v_i < 0$. If they travel to one of the other planets, further away from the sun, they will observe that $\Delta v_i > 0$. They may conclude that when we intend to travel from a small orbit to a bigger one, the spacecraft has to accelerate and vice-versa: When we intend to travel from a bigger orbit to a smaller one, the spacecraft has to decelerate. The fuel consumption is the same.

Delta-v velocities versus escape velocities v_e

If the students enter in a table the delta-v values for each journey and the escape velocity ve for each planet, they may observe that in some cases the two values are very close. For example, it is impossible to go from the Earth to Uranus on a Hohmann orbit, so alternative solutions should be found.

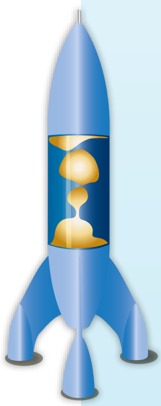
Possible damage to astronauts' bodies

Using the application, students have to compare the transfer time t for different journeys. They can see that the required travel time is much longer when considering the appropriate "launch window". In this case, they have to consider the physiological consequences of prolonged space travel in microgravity (for example, weakening of the bones and straining heart muscles) under X and Gamma radiation (damage to cells), and in conditions of longitudinal acceleration (overconcentration of the blood in the head or feet of the astronauts). The students should research the biological damages of space travel and prepare posters on this topic.

CONCLUSION

While pursuing these simulations, students will be able to enrich and compare their knowledge base about the Solar System and space travel. This will broaden their horizon and they will become aware of the different problems of space travel. As we already pointed out, it is an interdisciplinary concept, involving not only Physics and Informatics but also Biology and Mathematics.

To build on this subject, students may also want to learn about possible perturbations during this kind of travel such as: third body perturbation, perturbation from atmospheric drag, and perturbation from solar radiation. They may want to try using other orbital manoeuvres as gravitational slingshot and Oberth effects.



Software, Additional Materials and Outlook

SOFTWARE

With the introduction of their 2007 program, Scratch, experts at Boston's Massachusetts Institute of Technology (MIT) created a program intended to inspire children to try their hand at programming. The developers quickly realised that acceptance of this approach was highly dependent upon the level of success among young students. For that reason, they built a number of multi-media elements into their program. Scratch was aimed at children aged 10 and above, but was simultaneously used in an introductory programming course at the university level. Scratch can be downloaded at no cost at scratch.mit.edu. This site contains a wealth of ready-to-use projects that can also serve as wonderful inspirations for self-made activities.

For older students, most schools prefer to use Java as their programming language. Java programming is supported by a variety of integrated developer environments (IDE), the most popular of which are Eclipse (www.eclipse.org) and Netbeans (netbeans.org). These sites contain free, professional IDEs, which understandably require a certain amount of time before users are familiar with the inner workings of the programs.

The developer environment BlueJ has a considerably easier structure. It is used for teaching Java programming in many schools and universities.

Java is associated with a comprehensive collection of existing classes for various assignments. Learning Java consists primarily of researching its libraries and employing its contents. There are designated libraries for specific goals. These libraries are directly tied to the respective developer environments, and serve to expand the language. In the German-speaking classroom setting, the widespread use of the library "Stifte und Mäuse" (Pens and Mice) simplifies the many programming aspects for didactic purposes (www.mg-werl.de/sum). Open Source Physics (OSP) offers tools and libraries for programming physical situations (www.opensorcephysics.org).

Links to free video analysis software: Tracker (www.cabrillo.edu/~dbrown/tracker/), VirtualDub (www.virtualdub.org/).

Jürgen Czischke, Bernhard Schriek

ADDITIONAL MATERIALS · IBOOK

Additional material for these teaching units can be downloaded at www.science-on-stage.de. You can also find a PDF and iBook version of this publication there.

OUTLOOK

This publication remains a work in progress. If you are interested in our upcoming teacher trainings, or if you'd like to see how the project continues, please contact us via info@science-on-stage.de – new teachers are welcome to join!

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Overview of Activities: Project Events

2011

- 16–19 April
  Science on Stage Festival in Copenhagen
  Guiding theme: New Technologies in Science Teaching
- 4 July
  Coordinators' meeting in Dortmund
- 23–25 September
  First workshop in Paris

2012

- 18–20 February
  Second workshop in Berlin
- 8–9 November
  Presentation of results, teacher-training, and outlook in Berlin

2013

- 25–28 April
  Science on Stage Festival 2013 in Słubice – Frankfurt (Oder)
  Guiding theme: Information and Communications Technology
- Throughout the year
  Teacher trainings
  Teacher trainings in various European countries

Enthusiasm for Technology – FIRST LEGO League (FLL)

Enthusiastic children cheer on their robots. They cheer on its journeys and suffer, if it doesn't succeed in fulfilling its tasks. Young researchers explain current problems of society from the perspective of children's eyes and inspire teachers, professors and many other adults. These are just two facets of the educational program „FIRST LEGO League" (FLL).

Students aged 10 to 16 years can participate in this global robotics competition and so be introduced to science and new technologies in a playful way. Participants build and program an autonomous robot to solve difficult tasks. All teams also conduct research on a given topic and present their findings to an expert jury.

The idea and name for the training programme FIRST LEGO League were thought up by the U.S. non-profit organisation FIRST (For Inspiration and Recognition of Science and Technology). The LEGO Mindstorm robots served as the technical basis for the project. Within more than 10 years the FIRST LEGO League was established worldwide. The 2011 FLL took place in 54 countries, with almost 20,000 teams. In Central Europe the competition takes place under the patronage of the non-profit organisation HANDS on TECHNOLOGY e.V.

SAP has been supporting the FLL since 2005. To date, more than 1,000 colleagues in more than 25 countries provide coaches for participating teams.

For more information, visit www.firstlegoleague.de

erp4school – Use of Integrated Enterprise Software in Schools

erp4school – an interactive learning platform for illustrating business processes – was launched 10 years ago in Berlin, as part of the SAP University Alliances programme.

The future of work in the administration of companies lies in qualified and computerised workplaces. These positions require not only working with standard programs, but also a deeper understanding of a process-oriented workflow in business management, with a high degree of integration.

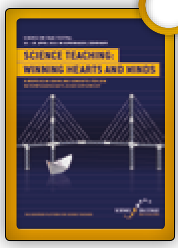
erp4school allows students to understand business and its processes as a whole. The students learn to work process-oriented. They recognise the ways in which a business operates and how parts of the business interact with each other.

Besides grasping the concept of self-organised learning, students also learn to use SAP systems in professional practice. The lesson concludes with an exam for obtaining an SAP certificate. By expanding the project beyond Germany, the SAP University Alliances programme has become a successful, international training project.

Contact:
erp4school@mmmbbs.de
ua-support@sap.com

Additional Materials

Please send me (one of) the following booklet(s):



Teaching Science in Europe 3
- Science in kindergarten and primary school
- Benefits of non-formal education initiatives
- Moderation of learning science

Science Teaching: Winning Hearts and Minds
- European teaching ideas for science classes

Laternenmond und heiße Ohren
- Improving language skills through science in primary school
- Experiments, work sheets, texts, etc.

To the following address:

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You can also send us your **order via email** to info@science-on-stage.de.
You can find all of our publications for **PDF download** at www.science-on-stage.de

The booklets are free of charge.

Membership

Please join the non-profit-association Science on Stage Germany as a member! The membership fee is 50 € per year. Please send an email with your name, address, school/institution to info@science-on-stage.de, or download the membership application at www.science-on-stage.de.

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The European Platform for Science Teachers

... is a network of and for science and technology teachers of all school levels
... provides a European platform for the exchange of teaching ideas
... highlights the importance of science and technology in schools and among the public

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