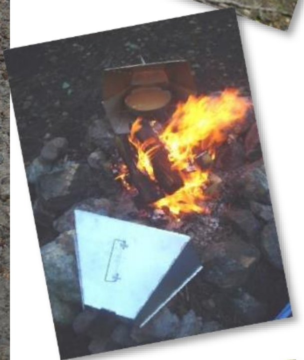
Nynäshamns kommun

Nynäshamns Naturskola

ÅK 6

Technology and sustainable future

Solar energy and simple machines



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Introduction

Nynäshamn Nature School was founded in 1988 and is currently receiving pupils from the grades of preschool up to year 9. The school classes have one nature school day a year – that's when they work with research around a certain theme. By writing tutorials for the teachers who come to the Nature School with their classes, we want to facilitate their preparation and follow-up work that they do in connection to the nature school day. We hope that this tutorial will contribute to a joyful outdoor learning of natural sciences and technology for the pupils in year 6.

Purpose

We want the pupils to have gained this knowledge after the day's theme:

- To understand that almost all energy comes from the sun (solar, wind, water, bio-fuel, geothermal heating (which is groundwater that has been heated by the sun), coal, oil and natural gas). Energy that does not come from the sun is the geothermal energy that contributed to 0,3% of the world's electricity production in 2007 but doesn't work in Sweden since it would require drilling boreholes of 1-2 km. Nuclear energy doesn't come from the sun either but is extracted from mineral (uranium).
- To know the simple machines and their purpose. The golden rule of mechanics "*whatever is lost in force, it is gained in displacement*". The reference to energy is that you spend less energy when less force is needed.
- That energy can neither be created nor destroyed, it can only be transformed or transferred from one form to another (thermo dynamics first main clause). A machine that breaks this natural rule is called eternal machine (perpetuum mobile) and doesn't exist. Finally, the energy emits into the sky as heat.
- Increased understanding that renewable energy sources are a must if we want to stop emitting too much of the carbon dioxide greenhouse gas, which stays in the atmosphere (other greenhouse gases are water vapor, methane, dinitrogen oxide), and to understand the difference between burning renewable fuel and fossil fuel (while at the same time understand that it is better not to burn at all and let the coal remain in the plants/trees).
- That technology is the human way to satisfy our needs by using produced devices and that we can choose and develop a technology that contributes to a sustainable future within the scope of the planet.
- That the most environmentally friendly energy is the one that is not used at all.

Practical information in brief

Location: Nynäshamn Nature School, Sjöudden, Ösmo

Time: 09.00-13.30

Break: The pupils bring their own snacks to the break in the morning.

Lunch: Will be brought from the kitchen of Vanstaskolan. Call 3562 if any child needs special food.

Clothes: According to weather, so don't wear any nice clothes. Spending time outdoors about 3,5 hours.

Phone no: 08-52073565, 52073709, 52073708

Agenda and content during the nature school day

Time	Activity	Comment
09.00	**Gathering around the camp fire** Light the fire – energy - Energy can neither be created nor destroyed, it can only be transformed or transferred from one form to another. Solar energy - Photosynthesis - Combustion - Reflector oven: a technical device used to reflect the heat towards the item we want to warm. Technology - Using produced devices to satisfy our needs (driving forces behind technology development). Examples: the digging bar (wedge and lever) to dig up roots. - What does technology mean to you? (alt. which technical devices did you use today before you came here?) - Technology in the neck (pictures of usual items) - Time rope with years to add different innovations on (pictures with clothes peg).	
09.30	**Break at the campfire** - Burn crispbread + candles (solar energy from the photosynthesis is re-released (chemical energy). Compare to burning/digesting the food and become warm and get kinetic energy.	
09.45	**Introduction to simple machines** - Christoffer Polhem – the father of Swedish mechanics, the alphabet of mechanics (the 'Polhem games' in Sorunda) - The golden rule of mechanics – whatever is lost in force, it is gained in displacement (to avoid using so much energy) - Presentation of the simple machines ○ Inclined plane/ramp (walk far and use less force or short distance but with more force) ○ Screw (compost turner, drilling machine) ○ Wedge (digging bar, broach, teeth, knife, obtuse short wedge requires more force) ○ Wheel (change direction of the force, some friction) ○ Lever (scale, seesaw, broach) ○ Block and tackle (often referred to as wheel or pulley)	

10.00	Divide into two groups.	

10.15	**Group 1 gathers indoors (together with their teacher)**
	- Build a solar cell car. In groups of 2-3 pupils.
	  o Construction (layout, create, test, change)
	  o Solar cells (energy transformation of solar energy to electric energy that becomes kinetic energy)	

10.15	**Group 2 gathers outdoors (together with the Nature School teachers)**
	- Slalom upwards and the catapult (seesaw with stone, stone with potential energy can make things happen).
	  o Whatever is lost in force, it is gained in displacement.
	  o Energy transformations (solar energy, chemical energy, kinetic energy, potential energy, heat).
	- Go through the stations.
	<u>Three stations</u>
	- Block and tackle (lift others and yourself).
	- Lift a child in a seat using different wedges.
	- Move box with a child inside (lever, wedge, wheel, inclined plane, problem solving). Task: Use as many simple machines as possible.	

11.15	Lunch (outdoors or indoors depending on the weather).	
11.50	Group 1 is now outdoors and group 2 is indoors.	
12.00	Work in half class.	
13.00	**Everyone gathers outdoors** - Conclusive activity of simple machines: o Remove one of four technical everyday items (artifacts). - Backup. The nose (clues to items or terms). - Evaluation of the day. - Backup. Energy radiations (activity from the 'HUT'-book ('Sustainable Development')) or similar with the purpose of understanding the greenhouse effect and why energy from sun, wind and water is better than fossil fuels.	
13.30	The day ends.	

Preparation work

To gain as much knowledge as possible during the day, the pupils must come prepared. Depending of what they have done previously in school, the classes can prepare themselves in different ways. Since the theme touches upon several subjects: natural sciences, technology, mathematics, social sciences, history and sustainable development, it is recommended for different teachers to cooperate, i.e. cooperation between class mentors (in the subjects concerning life style issues, social society development, history, mathematics), teachers of natural sciences (energy, photosynthesis, combustion) and technology teachers (fossil free technology, simple machines). This will increase the pupils' chance of obtaining instructive preparation and follow-up work.

Concepts that the pupils should know before this day, in priority order:

1. Energy
2. Energy transformation (solar energy, chemical energy, kinetic energy, potential energy, heat)
3. Fossil fuel (non-renewable fuel)
4. Renewable energy
5. Solar cells (the pupils will build solar cell cars using LEGO during the nature school day). For information to the teacher, the drawings are attached here, since the class mentor will be together with the group that builds the solar cell car.
6. Simple machines (these will be presented during the nature school day, and activities will be done where the children can try out the various simple machines).

Concepts 1-5 are listed in the references on next page.

What is energy?
Energy is a feature with which a device can perform work. This means that by using force the device can affect another device to move in the direction of the force.

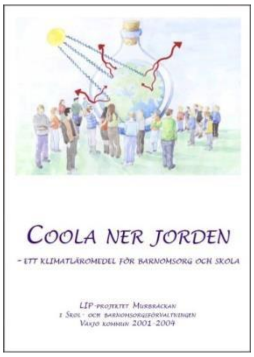
Fuels
<u>Renewable fuels</u>: wood, pellet from harvest waste, plant oils, e.g. rapeseed, ethanol, biogas (e.g. marsh gas from mud, gas from retting of food waste).
<u>Fossil fuels</u>: Oil, coal (brown and black), peat, natural gas.

The alphabet of mechanics
Carl Johan Cronstedt, a student of Polhem, wrote in 1729 about the benefits of such a model collection of the alphabet of mechanics: *"As a writer must know all the letters of the alphabet to read and write, an engineer must have all the basic elements of mechanics in his head…"*

To read during the preparation and follow-up work

Cool down the earth

The following pages are extracts from the '*Coola ner jorden'* leaflet (translated: *Cool down the earth*). The leaflet is a few years old but is still very good concerning general facts about energy. We have chosen these pages, which are useful during the preparation work:



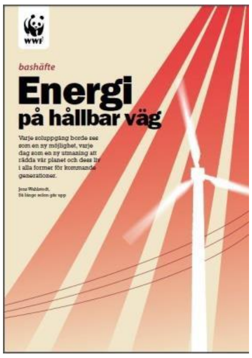
p.24 about energy.
p.25 about energy types.
p.26 about renewable and non-renewable energy resources.
p.33 about energy transformation.
p.36 about the energy chains of the energy sources.
p.38-41 energy cards used as copy materials.

p.53 about the candle.
p.55 about water power
p.57 about wind power.
p.59 about coal, oil and petrol.
p.61 about rapeseed oil.
p.67 about wood.

<u>*Copy materials*</u> (energy cards) to be used by the pupils to make energy chains for them to reflect and discuss with the purpose of making them understand that energy can never be destroyed, only be transformed. The page about the candle is a repetition of what we discussed in grade 5 during the fire theme. Download the complete leaflet as PDF here: *Coola ner jorden.*
Web address: http://static.wm3.se/sites/2/media/23097_COOLA_ner_Jorden.pdf?1415197966

Energy in a sustainable way

Another leaflet on the web is '*Energi på hållbar väg'* by WWF (translated: *Energy in a sustainable way*), which is newer but with similar content. The informative sections are partly better since they are statistically updated. This basic leaflet can be downloaded here, as sections or complete.
Web address for teaching materials in English:
https://www.wwf.se/utbildning/wwf-education/material/



Pages suitable during the preparation or follow-up work:
<u>Preparation work</u>
p. 11-12 about the view of WWF on non-renewable and renewable energy.
p. 13-16 about energy theory.
p. 22-23 about energy and life.
p. 30-36 about the greenhouse effect.
p. 38-45 about energy sources in the society.
<u>Follow-up work</u>
p. 26 about the jack-in-the-box – effect.
p. 27 about the crispbread.

The '*Boken om naturvetenskap'* (translated: *Book about natural sciences*) by Experimentskafferiet contains useful descriptions about energy on pages 152-160. <u>Download the book</u>.
Web address: http://www.experimentskafferiet.se/merinfo/faktabok.php

Attached is a leaflet (extract from a newsletter) with examples of new exciting technology for a fossil free future, with the purpose of giving the pupils a hope for the future and making them see the possibilities with technology development as part of the solution to the climate crisis.

The nature school day

At the campfire

All children gather around the campfire for introductory conversations about energy and eco cycles. We have put our closed-loop system at the campfire in the form of a demi-join with earth and plants that we have kept indoors by the window since 1998.

Light the fire

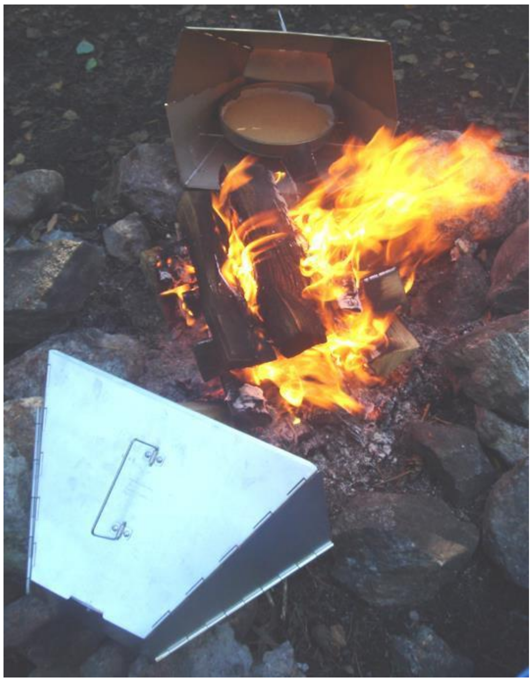
We have prepared two reflector ovens with a frying pan in each. Baking paper is in the bottom and a batch of muffin or sponge cake is divided in the two pans. Baking using a reflector oven should be done when there are still fire flames. Only fire glow is not enough. When the children are gathered, we light the fire, either using a lighter, fire steel or matches, and at the same time take the opportunity to remind them about the last time we met when they were in the 5th grade and had the fire theme on the agenda.

Examples of energy transformations

Example 1, eat food:
Solar energy (radiant energy) – chemical energy (photosynthesis) – kinetic energy – heat.

Example 2, fire:
Solar energy (radiant energy) – chemical energy (photosynthesis) – heat and light (radiation energy).

Example 3, drop a stone from height:
Solar energy (radiant energy) – chemical energy (photosynthesis) – kinetic energy (move the stone upwards to a height) – heat (body heat + friction between feet and ground), potential energy (due to gravitation), kinetic energy (the stone falls), friction gives heat (air-resistance, collision with molecules), heat and deformation (friction when hitting the ground + the ground is deformed (kinetic energy)).



About 15 cm is enough distance between the reflector oven and the fire flames.

Solar energy and technology

When the fire is burning, we talk about what fire is and where the energy in the wood comes from. We repeat some things from the day here when they were in the 5th grade and made fires. We use the reflector oven as an example of artifact, a technical device, that directs the radiant energy towards the items we want to heat up.

Describing the photosynthesis

To give the children a more concrete picture of the abstract photosynthesis, we have chosen to demonstrate it using a pot. We put sugar cubes in the bottom as building blocks. A piece of wood or wooden discs with annual rings. Drinking straws to blow carbon dioxide through (through hole in the lid = stoma). A tube through hole alongside the handle that sucks up the water.

The jar with the plants that haven't been opened since 1998 arouses many questions. This is a good start for discussions about the atmosphere and the greenhouse effect.

An example to show the photosynthesis. A green pot resembling a leaf. Green marbles as chlorophyll and sugar cubes (building blocks) resembling the sugar that is produced in the process.

Why are the leaves green?
Chlorophyll absorbs blue and red light and that energy is used during the photosynthesis. The green light is reflected.

Energy can neither be created nor be destroyed, it can only be transformed or transferred from one form to another.

Photosynthesis $6H_2O + 6CO_2 + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$
Water and carbon dioxide are chemically transformed into glucose (mono saccharide) through solar energy. The oxygen in the carbon dioxide emits from the leaves while the coal joins to the water and produces carbohydrates. The glucose is joined in pairs to sucrose (disaccharide, e.g. cane sugar). When several hundred/thousands of glucose molecules are joined, then starch and cellulose are produced (polysaccharides). Note that also plants need oxygen for their cellular respiration, it is only the surplus of the oxygen (from the carbon dioxide) that leaves the plant's stoma. This means that the plants use oxygen and emit carbon dioxide at the same time as the ongoing photosynthesis. During the nights, they only emit carbon dioxide just like any other organism since photosynthesis is not possible at night.

Combustion
When we eat plants, the starch is digested both in the mouth (using an enzyme called amylase), stomach and intestines, into glucose, which is then absorbed by the blood and can be used by the muscles as energy for us to do work and movements. The glucose is burnt in the muscles through the process when coal in the food is joined with the oxygen that we breathe. During this process water is also produced, which we will later urinate. The carbon dioxide is transported by the blood and leaves our lungs when we exhale. Take a bite of crispbread and describe the taste. Continue to chew without swallowing until all is finely divided. Describe the taste and compare by taking one more bite. The chewed slurry mass should taste sweeter since the amylase has digested the starch into sugar.

Technology

We talk about the term technology and the driving forces behind technology development.

- What does technology mean to you? (or: which technical device did you use today before you came here?)
- Definition of the term technology. *Using produced devices to satisfy our needs*. We show the digging stick (wedge and lever) as example of an artifact used by the hunter-gatherers during the older stone age. To satisfy the need for food by digging up roots that are rich in carbohydrates have been the driving force behind the development of the digging stick.
- We have prepared by putting up a timeline rope between two trees. The pupils get pictures with different inventions that they discuss about in pairs, and then hang the pictures at the appropriate year on the timeline rope. Most innovations are such that we today take for granted, for example the computer and toothbrush.

The digging stick was a simple tool, i.e. the result of technology development based on the driving force to find food, in for example roots.

A timeline rope in the range from 4000 BC until now.

Break at the campfire

During the break, the children are served the sponge cake that was baked for about half an hour in the reflector oven.

- To visualize the resemblance between digestion in our bodies (that gives heat and kinetic energy) and the combustion that occurs in the fire, we burn a piece of crispbread (solar energy is released from the photosynthesis again during the burning (chemical energy) by the oxygen reacting with the coal so that heat, light, water and carbon dioxide are released).
- During the break we talk to the teacher about the activities during the day and about the preparation and follow-up work.

A crispbread is burnt and provides heat and light that originally come from the sun.

Sponge cake enough for the whole class to eat. The energy in the wood has been stored chemically through the photosynthesis. The heat that originated from the sun has baked the cake.

Introduction to simple machines

The simple machines are principles whose characteristics are used in many daily devices. With the simple machines we don't need to use so much force and therefore less energy is needed.

- Since Christoffer Polhem worked at Vansta Manor in Ösmo, there is a natural connection to Nynäshamn Nature School, which house in Ösmo was built by the owners of Vansta Manor in 1905. Christoffer Polhem – the father of Swedish mechanics – lived and worked at Vansta Manor in Ösmo in the end of 1600. His life here and at Fållnäs has been staged in the 'Polhem games' in Sorunda for several years.
- We introduce the simple machines, sometimes also called the 'ancient mighty five', by showing several different items. The golden rule of mechanics – *whatever is lost in force, it is gained in displacement.*
  Mechanics is the branch of Physics dealing with the study of motion (kinematics) and force (dynamics).

The mechanical alphabet
The alphabet of mechanics consists of 79 pedagogical wooden models where the five vowels a, e, i, o, u, stand for these five simple machines (the five mechanical vowels): lever, wheel, screw, block and wedge. The consonants consist of unlimited number of technical principals such as chains, joints, springs, links, straps, wires, coils, etc. The simple machines (vowels) and the consonants together become composed machines (such as the old drilling machine).

Christopher Polhem…
…at that time named Polhammar, was a farmhand at Vansta Manor in Ösmo 1685. In 1687 he started studying physics, mechanics and mathematics at Uppsala University and thereafter travelled around Europe to learn more about technology. Back home in Sweden he started the first school for engineers in 1697.

Inclined plane (the ramp)

By extending the distance you don't need to use so much force. For example, when walking the long curvy road up the hill with two heavy bags, the distance become longer than walking straight up the hill. Your legs can manage since you don't need as much force going upwards a flat slope compared to a short and steep slope. Compare this to serpentine road, wheelchair ramp, stairs and spiral staircase. When the pyramids in Egypt were built, they used long ramps of gravel to move the big stone blocks.

A ramp, an inclined plane.

Screw (compost turner, drilling machine)

The screw is usually described as a movable narrow-inclined plane wrapped around a cylinder. Compare it to a spiral staircase; it is long, but it does not take so much effort to walk upwards compared to climbing a ladder. The same with the screw; it turns many times, taking long time to dig in but not so much force is needed as when pushing for example a nail straight in.

The screw, a simple machine

The golden rule of Mechanics
– whatever is lost in force, it is gained in displacement.

Wedge (digging stick, broach, teeth, knife)

A wedge consists of two ends; one sharp and one blunt (two inclined angles). The vertical force used against the broad/blunt part of the wedge gives horizontal force to the sides.

With a short blunt wedge, you can do a job faster than using a long wedge with a narrow angle, but it requires more force. A long narrow sharp wedge does not require as much force, but it takes longer time to cut (more strikes) and the distance to dig in is longer. A wedge can be used to separate an object, for example to cut wood with an axe or chop onions with a knife.

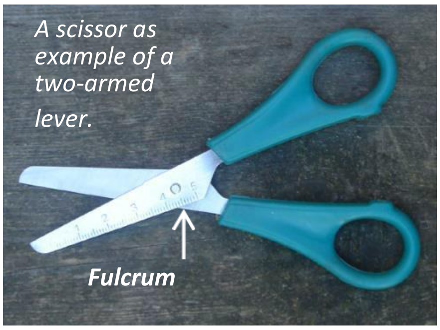
Wheel (pram wheel, pulleys in block and tackle)

The wheel is seen as one of the oldest inventions and the potter's wheel is seen as the first usable wheel. The big advantage with wheels is that the problem with friction is reduced. When wheels are used on vehicles, they work optimal on flat and even ground. Therefore, the most important field of usage for the wheel occurred when railroads were invented, and later also when we got asphalted roads.

Without wheels, like a sledge, there will be so much friction, so a lot of force is needed. Using horses, it is possible to pull a sledge, especially in winter, which reduces the friction substantially. Note that without friction at all, the wheel will not roll (only slide), so friction between the wheel and ground is a condition for the wheel to roll.

The wheel, one of the simple machines

Lever (scale, seesaw, digging stick, scissors)



A lever is a long narrow device that performs work at one end (output) through force being provided at the other end (input).

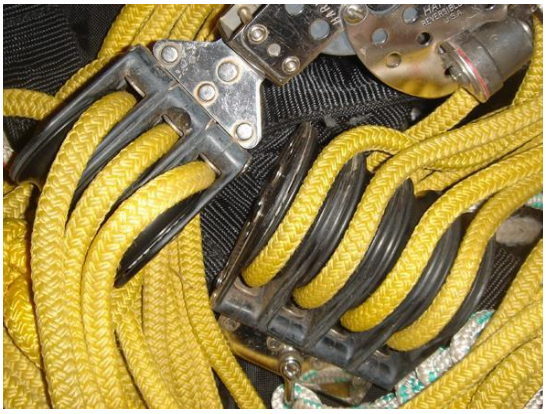
An example is a digging bar that can be used to budge a stone. The longer the *lever arm* is, the more force is gained. Somewhere on the lever there is a spot called *fulcrum*. Levers can be *one-armed* or *two-armed*. Examples of one-armed levers are nut crackers, wheelbarrows and tweezers. The fulcrum is then located at one end, and the force that is provided and the work performed are on the same side of the fulcrum. The nut cracks on the same side of the fulcrum (hinge) as where you hold your hand.

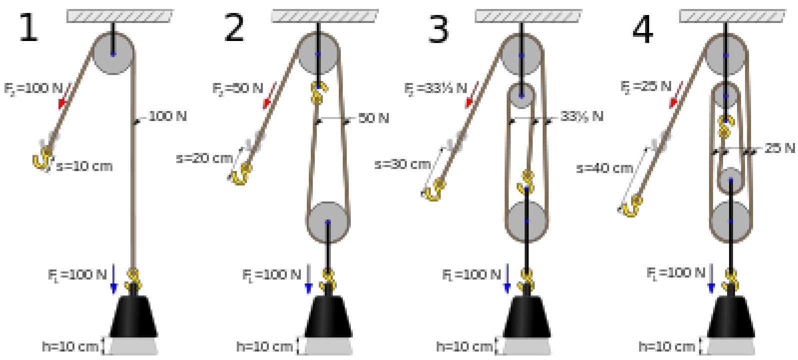
Examples of two-armed levers are seesaws, scales and scissors. The fulcrum is located between the provided force and the other end where the work is performed. The force is provided to one end of the scissor by the hand, the string is cut off in the other end of the scissor and the fulcrum is located where the two blades are joined.


Digging bar as example of a lever.

Block and tackle

Block and tackle are often seen as the 6th simple machine. But it is also considered a wheel. Several wheels (pulleys) that are joined together are called block and the complete construction with two blocks and rope is called tackle. The wheels in the block change the direction of the force. With only one wheel no force is gained, only the direction of the force is changed. The load is distributed along the rope, so the more the rope is pulled, the easier it is. But there must be wheels that change the direction, it will not become easier just because you have a long rope. It is the wheels that cause the load of the object to be distributed along the length of the rope. In illustration 4 below, the object will move upwards 25 cm if I pull the rope 1 m. I have lost in distance but gained in force.





Block and tackles are of different sizes. We use big blocks and thick strong rope so that we can lift the children safely a bit above the ground.

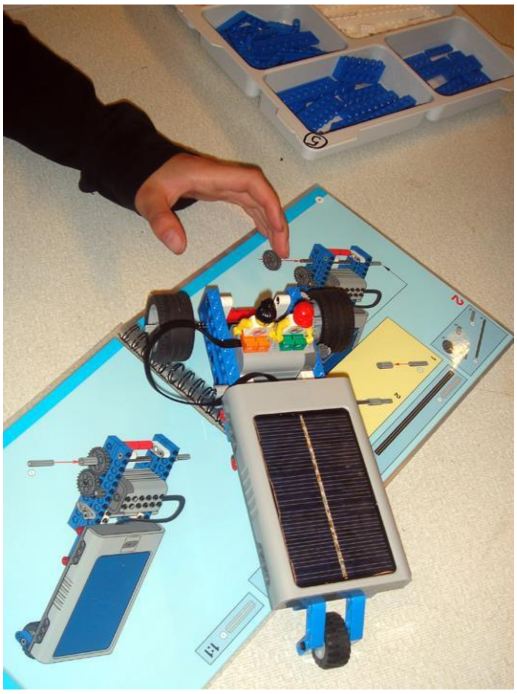
Image from https://sv.wikipedia.org/wiki/Block_(enkel_maskin)

1. No gain in force and no loss in displacement (the wheel only changes the direction of the force).
2. Pull the rope twice as much and it will become half as heavy.
3. Pull the rope three times more and it will become a third as heavy.
4. Pull the rope four times more and it will become a quarter as heavy (100 kg becomes 25 kg).

Group 1 gathers indoors

The class is divided into two groups. Divide the indoor group into five smaller groups with a maximum of three children in each group. Each small group should build solar cell cars using Lego. The building kits used are Lego Education. The children then try out their cars outdoors in the sunlight. If the sun does not shine, they can use work lights, indoors or outdoors. The teacher is together with the indoor group. See attached drawings, for information.

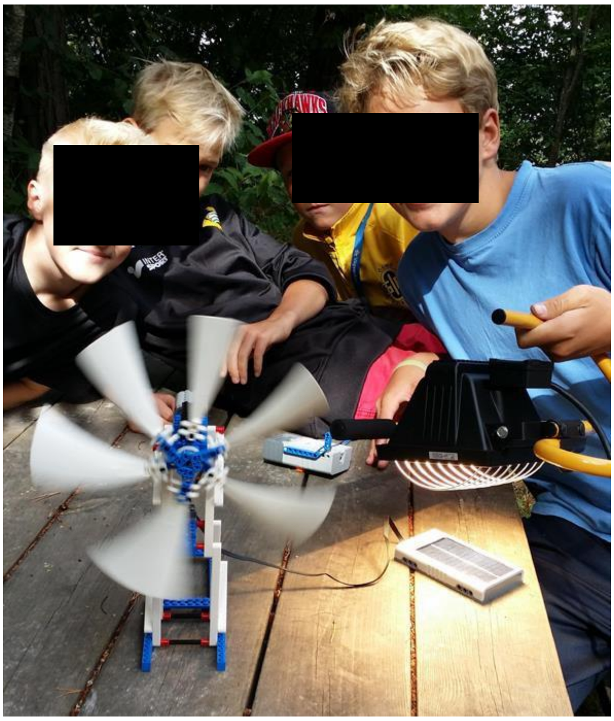
- Construction (the process: idea, create, test, change).
- Solar cells (energy transformation of solar energy (radiation) to electric energy that becomes kinetic energy).



The groups of 2-3 pupils are indoors building solar cell cars. Those who want can also make other solar cell constructions.

Solar cell

A solar cell consists of two layers. The most common material in the solar cell's layer is silicon. One layer is positively charged and the other one is negatively charged. When the sun shines, the layer is hit by photons which are energy particles from the sun. The negative layer absorbs the photons and finally there is a voltaic difference between the layers through which the electrons get the energy (they excite). These electrons are then transported in electric wire, and thus electric current has been created.



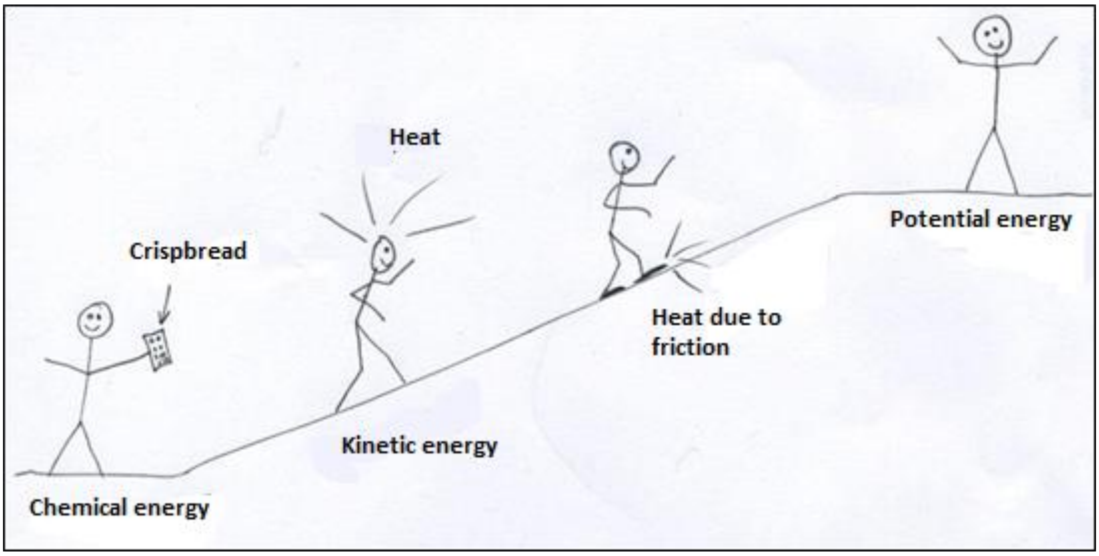
Depending on the weather, they can try out their cars outdoors in the sun. Use work lights if it is cloudy.

Group 2 gathers outdoors

Up and down the hills, and slalom upwards

The rest of the class gathers outside. We stand on top of a hill and then walk down the hill. When down, we chew some crispbread to illustrate how energy transformation works. The *chemical energy* in the crispbread originates from the sun and inside the body it now transforms into *kinetic energy*. We walk up the hill again. When up, we will notice that some of the energy has turned into *heat* in our muscles but also through the friction between shoes and ground. It was quite tiresome to walk straight up the hill, but now we have got *potential energy*, which helps us to walk down the hill again by transforming into *kinetic energy* and *heat*. That was much easier. To save some energy we can use a simple machine on the way up. By walking slalom up the hill, the distance becomes longer but we don't need as much force and therefore not as much energy.

- Whatever is lost in force, it is gained in displacement
- Energy transformations (solar energy, chemical energy, kinetic energy, potential energy, heat).



Compare with:

The water is moved into a hydroelectric dam - originally by the sun through *kinetic energy* (evaporated) forming into clouds (condensed) and transforming into *potential energy*. The gravitation makes the condensed water finally to fall out as rain and move into the hydroelectric dam. When the dam is opened the water drops downwards and the potential energy converts into *kinetic energy.* The water drives the turbines, causing them to rotate which releases kinetic energy, which is converted into *electric energy* through a generator. Examples of older turbines are waterwheels and windmills.

Energy chain

An energy chain with energy forms and energy transformations, illustrating that it is the solar energy driving the hydroelectric dam:

Energy forms

Radiation	heat/kinetic/ potential	potential/kinetic	electric	radiation/heat

Image from the folder '*Coola ner jorden*'.

Catapult

After walking up and down the hill, we gather in a circle to demonstrate energy transformations using a simple machine (lever). A stone (2-3 kg) is lying on the ground. We tell the children that the stone doesn't have any energy, so it cannot cause anything to happen because of that. On the ground there is also a small seesaw in the shape of a wooden plank (about 50 cm) on a piece of wood. On the plank there is a plastic jar. We lift the stone slowly and tell the children that with our chemical energy in our body (that comes from food) we can lift the stone using kinetic energy. And when the stone is lifted, it has got potential energy which it didn't have when lying on the ground. Thanks to gravitation, the stone has potential energy that we now could use. The stone can make things happen since it is filled with energy. We put the stone on the seesaw and catch the jar with our hands.

When we dropped the stone, the potential energy was converted to kinetic energy, which was transferred through the lever to the jar in our hands, and the jar gets the potential energy instead of the stone. Some energy has also converted to heat by the friction and some to kinetic energy on the ground when the lever hit and deformed the ground. The plank is also deformed by the stone.

A way to illustrate energy transformations. A stone without energy on the ground cannot make anything happen. But if it is lifted, it gets potential energy, which can cause things to happen. Several steps of energy transformations become visible in this simple demonstration.

Energy

Energy is a feature that can make things happen.

Experience simple machines

The children are divided into three groups with a maximum of five in each group. We show them the three stations where they should perform assignments for about 10-15 minutes per station. We both show and tell them about the assignments without revealing how to solve them. There are also short instructions at the stations to read if they need.

Block and tackle

At this station we have prepared with two block and tackles. One has one wheel and the other one has seven wheels.

Assignment:

One child sits in the "chair" and one or more children lift by pulling the rope.

- How far do you pull the rope and how far is your friend lifted?
- Can you lift yourself?
- If there is only one wheel (i.e. you gain nothing in force), how much weight can you lift then?
- In which situations is this machine useful?

Materials: Two block and tackles with seats and measuring tape. A spring balance is attached to the rope to show the weight of the one sitting in the "chair".

It is heavy for the two children who are lifting their friend when there is only one wheel in the block and tackle. They don't gain any force and don't lose any distance. For security reasons, we have made a knot on the rope so that the children cannot lift each other too high.

What happens?
The children lift each other using the block and tackle that has only one wheel. The realize that it is very heavy. A person that weighs less than the person being lifted cannot manage but will be hanging, holding the rope. It is only possible to lift items that weigh less if there is only one wheel since we don't gain any force and don't lose any distance. The children can also see this by measuring how far they can pull the rope and then measure how high the seat is lifted. The seat is lifted exactly as high as the length of the rope that is pulled. When the children lift the person sitting in the seat and there are two blocks with seven wheels altogether, it becomes much easier. They can lift a person who is heavier than themselves. They can even lift themselves.

If they lift a person one meter off the ground and then measure the rope used, they will see that the rope was pulled out 7 meters. If they put the spring balance on the rope, they will see that the person weighs 6 kg (when sitting still and they are not pulling the rope), although the person really weighs 42 kg. They have gained in force since the person only weighs 6 kg, i.e. one seventh. But they have pulled out the rope 7 times more than the child has been lifted. So, they have actually lost as much in displacement.

Wedge

We have prepared by using three poles to hold the planks in place.

Assignment:
One or two children stand on the pile of planks. The others should lift the child (or children) by inserting wedges between the planks using the rubber mallets.

- How high can you lift without anyone falling off? Measure!
- Can you lift yourself?
- Which type of wedge is easiest to insert?
- When is this simple machine useful?

Materials: Planks, wedges, rubber mallets, ruler or inch rule

What happens?
By inserting wedges between the planks, the children can lift something that is heavier than themselves. The force against the blunt part of the wedge is not straight towards the point but along the sides and therefore the plank can be lifted. Long narrow wedges are easier to hammer than short and blunt ones. It requires more force to hammer using short blunt wedges. Besides the wedges, the children use levers in the shape of rubber mallets to hammer the wedges.

By inserting wedges between the planks, the children can lift each other. We use rubber mallets for safety reasons, and also for the wedges not to break.

Lever, wedge, wheel, inclined plane

On the ground there is a log, and a box which is placed 5 meters away from the log.

<u>Assignment:</u>

You should use as many simple machines as possible when solving this assignment. One or two children sit down in the box. The others should move the box using as many simple machines as possible

- Can you move the box over the log without the children who are inside the box will fall out?
- How fast can you move the box over the log? Measure the time!
- Is it possible to move yourself when you’re inside the box?
- Which simple machines did you use to solve the assignment?

<u>Materials</u>: Box, poles, planks, digging bar, ropes, wedges

<u>What happens?</u>

The children put out poles on the ground and then ties the box with the rope. Using the digging bar, they lift one side of the box up on top of the poles and start pulling the rope. The poles work as wheels and are moved successively in front of the box. Planks are put as a ramp onto the log and a ramp down on the other side. Alternatively, they can use a long board that tips over as a seesaw, when the box is on top of the log.

If the children choose to build a ramp of the short boards, they will notice that they need more force to push or pull the box over the log. Using long boards does not require as much force, but it takes longer time (distance) on the ramp.

The children should use as many simple machines as possible to solve the assignment of moving a heavy box about 15 meters, and over a log.

The children are here using both wheels and inclined planes to solve the assignment.

Everybody gathers outdoors

When the day is coming to an end, we gather outdoors. We evaluate the day and the children can tell us what was good during the day and if there's something they think could have been done in another way.

- We finish the day with a classical activity where four everyday items (artifacts) are put on a white cloth. Three items have something in common and one should be removed.

Backup activities

- Energy rays (activity from *Learning sustainable development outdoors*) or similar activity with the purpose of understanding the greenhouse effect and why energy from the sun, wind and water is better than fossil fuels.
  The sun rays that reach the surface of the earth are absorbed and the surface is warmed up. Then the heat radiates (infrared) but on the way out the heat is absorbed by molecules in the atmosphere. Some of the heat is then further emitted into the space while some is radiated back to earth. Some of the sun rays are directly reflected by clouds or the earth's surface. Water vapor and carbon dioxide are the most important greenhouse gases.
- The nose (clues to items or terms).

Life without simple machines
How would everyday life be without simple machines? Which challenges would we encounter in school and at home?

Greenhouse effect

The greenhouse effect is the effect that makes the heat remain around the earth and is not emitted into space. The greenhouse effect makes the average temperature 33 degrees warmer than if it did not exist at all, +14 instead of -19. This effect is a condition for life on earth. The atmosphere that consists of different gases works like a lid that stops heat from emitting into space. The sunlight penetrates the atmosphere and reaches the earth relatively easy. The ground absorbs the sunlight while bright surfaces like snow reflect much of the light directly. The ground is warmed up and emits heat in the form of long wave infrared heat radiation. We cannot see this radiation, which is stopped by gases in the atmosphere, e.g. water vapor and carbon dioxide, that absorb the heat. The heat is then emitted in all directions, both into space but also back to earth. So, it works as a greenhouse made of glass where the sunrays go through the glass and warm up the ground and air. When the heat radiates it bounces back by the glass walls and glass roof. But some heat also leaves the greenhouse just like some heat in the atmosphere is let out into space. So, the problem is not the greenhouse effect per se, but the ***amplified*** greenhouse effect that is a result of the increased absorbing greenhouse gases in the atmosphere.

Another amplifier is the melting ice and snow at the poles, which normally reflect the sunlight through their bright surface. When ice melts and reveals the darker water or when the snow melts and reveal the dark ground, then the absorption of the solar energy is increased.

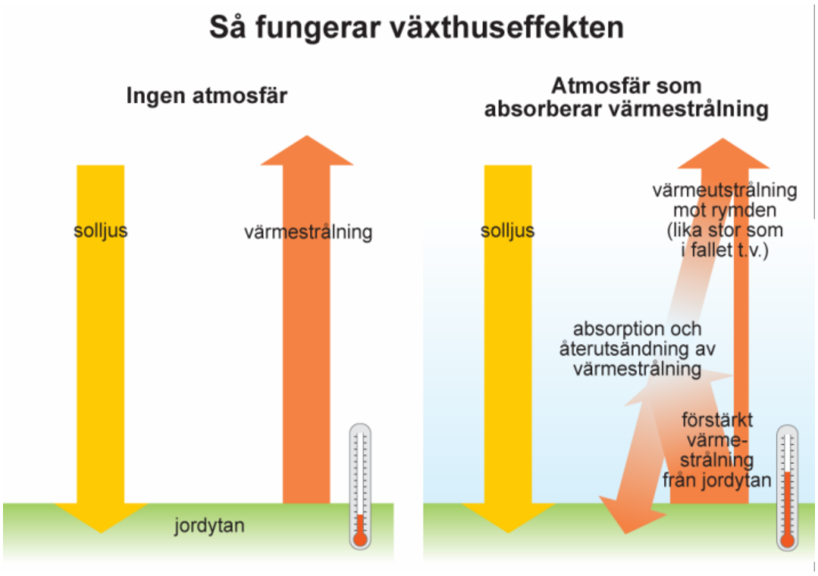


Image from http://sv.wikipedia.org/wiki/V%C3%A4xthuseffekten

Greenhouse gases

The picture below shows that the most intensive sun radiation is mostly not stopped at all. It is only water vapor, oxygen and ozone that absorb the sunlight to some extent. This is mentioned below as a “window”. The outgoing heat radiation is mainly stopped by water vapor and in the most intensive waveband it is the carbon dioxide that stops most of the heat from being emitted into space (below marked as “closed window”). In the picture you can also see the important functions that oxygen and ozone have as being shields to stop the dangerous ultraviolet radiation from the sun.

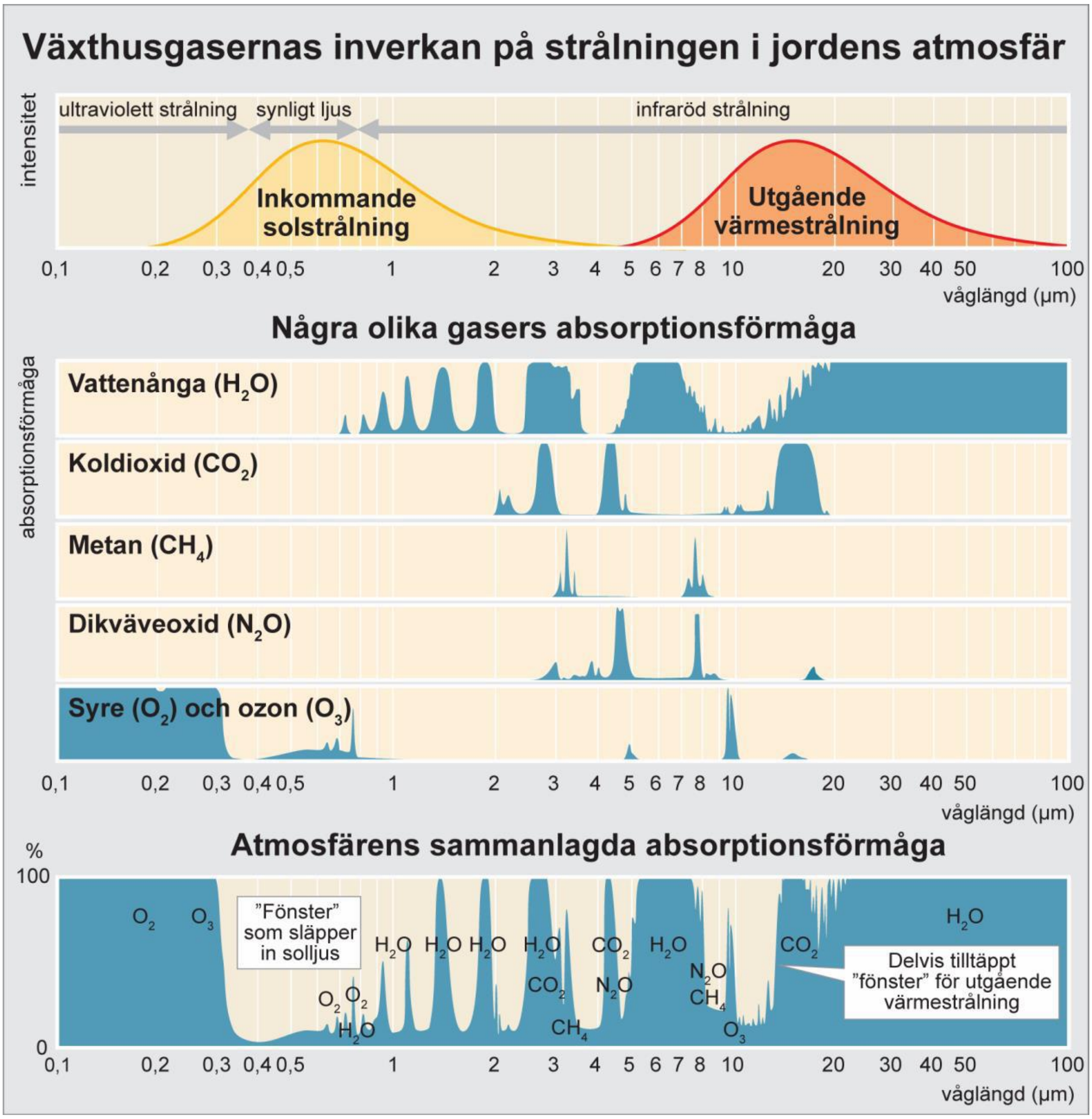


Image from http://sv.wikipedia.org/wiki/V%C3%A4xthuseffekten

Main content of the Technology syllabus, years 4-6

- Everyday objects consisting of moving parts and how these are linked together by means of different mechanisms for transferring and reinforcing power
- Solid and stable constructions (houses, bridges)
- Electrical components
- Components in simple technical systems (torches)
- Common materials (wood, glass, concrete)
- Words and terms
- Different phases of technical development (identification of needs, investigating, proposing solutions, designing and testing)
- Pupils' own constructions (solid and stable structures, mechanisms and electrical connections)
- Documentation (sketches, terms, symbols, measurements)
- Common technical systems at home and how they have changed over time
- Economising the use of energy in the home
- Consequences of technological choices, (advantages and disadvantages of different technological solutions)

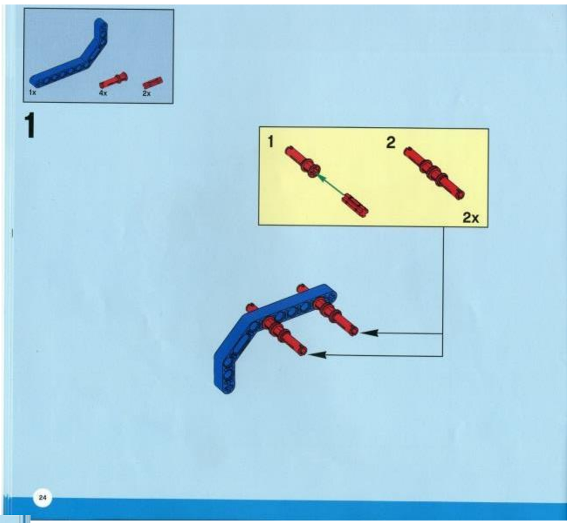
Abilities in Technology

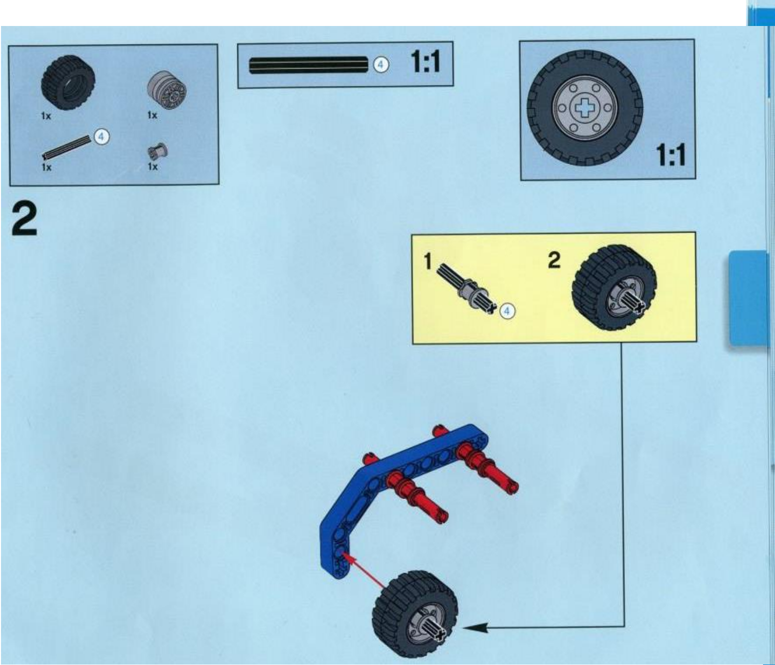
- Identify and analyse technological solutions based on their appropriateness and function
- Identify problems and needs that can be solved by means of technology, and work out proposals for solutions
- Use the concepts and expressions of technology
- Assess the consequences of different technological choices
- Analyse the driving forces of technological development

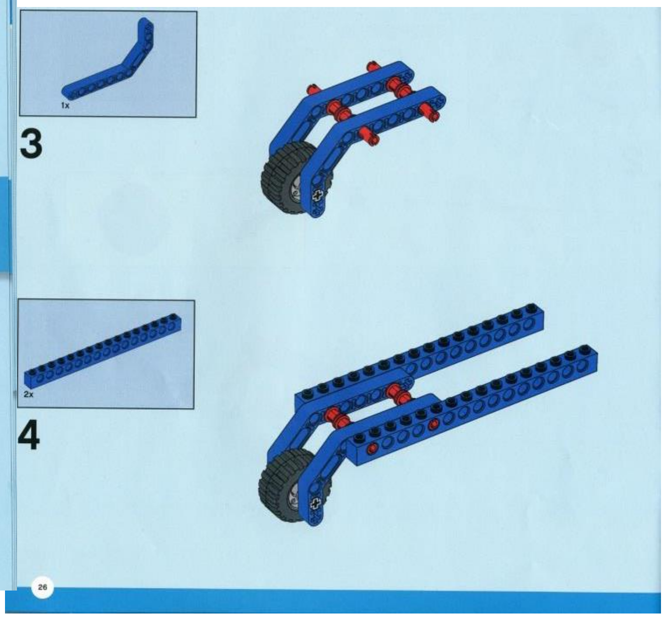
Main content of the Physics syllabus, years 4-6

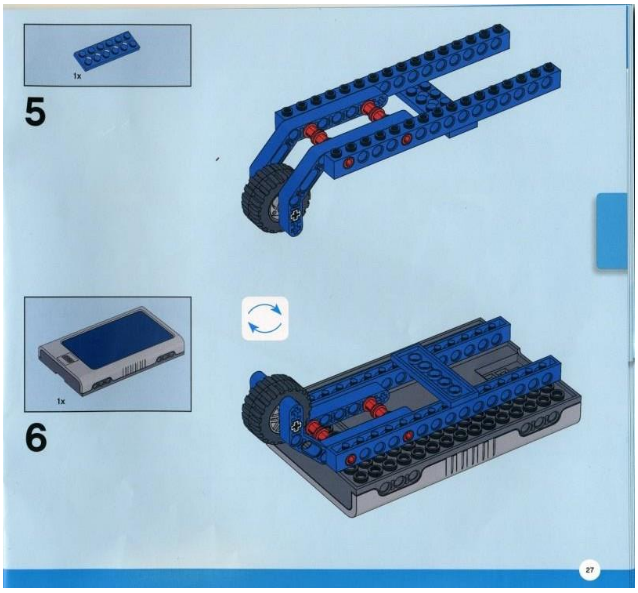
- Indestructibility of energy and flows, different types of energy sources and their impact on the environment
- Metrological phenomena (e.g. how wind occurs)
- Energy flows between objects with different temperatures (clothes, house insulation, thermos)
- Electrical circuits with batteries (torches)
- Magnets
- Forces and motion in everyday situations (e.g. cycling)
- How sound occurs
- Distribution of light
- Some historical and contemporary discoveries
- Different cultures – their descriptions of nature in literature and science
- The planets of the solar system (years and seasons)

Half of the class is indoors (together with their mentor). LEGO building instructions for the teachers (for information). Construction step 1. Carriage body with solar cell panel.

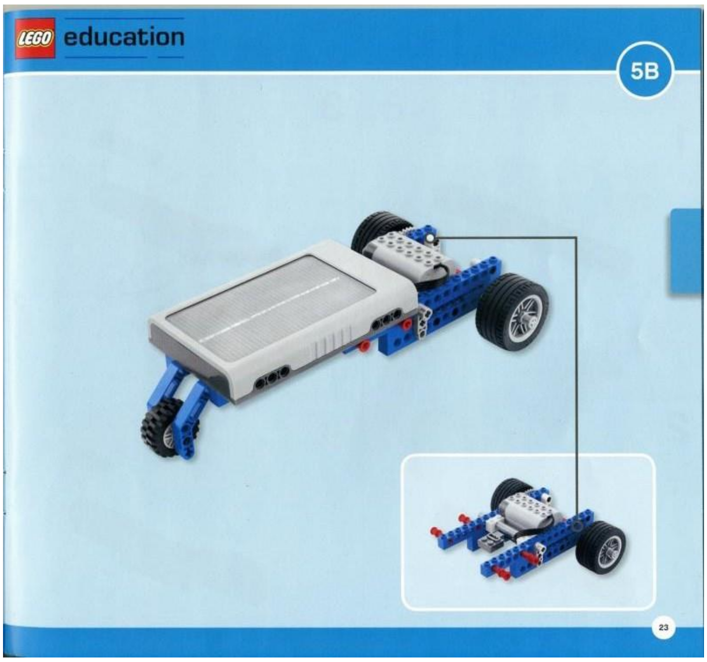


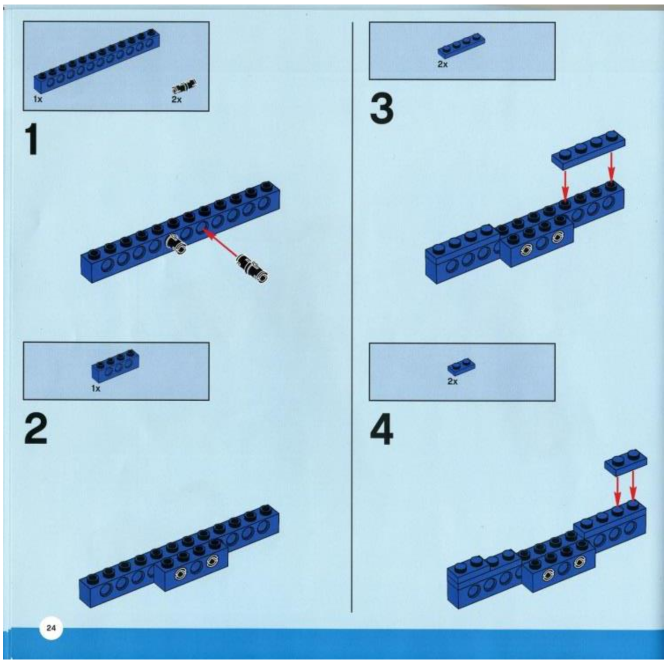


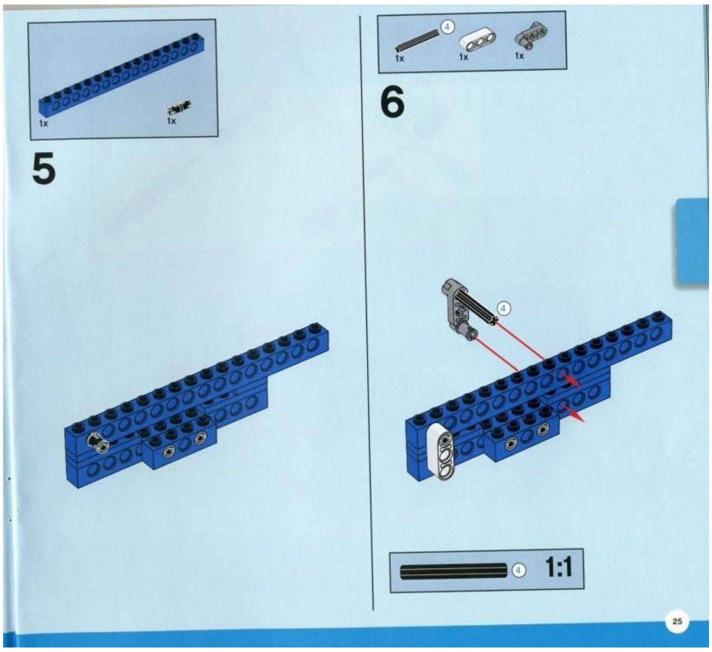


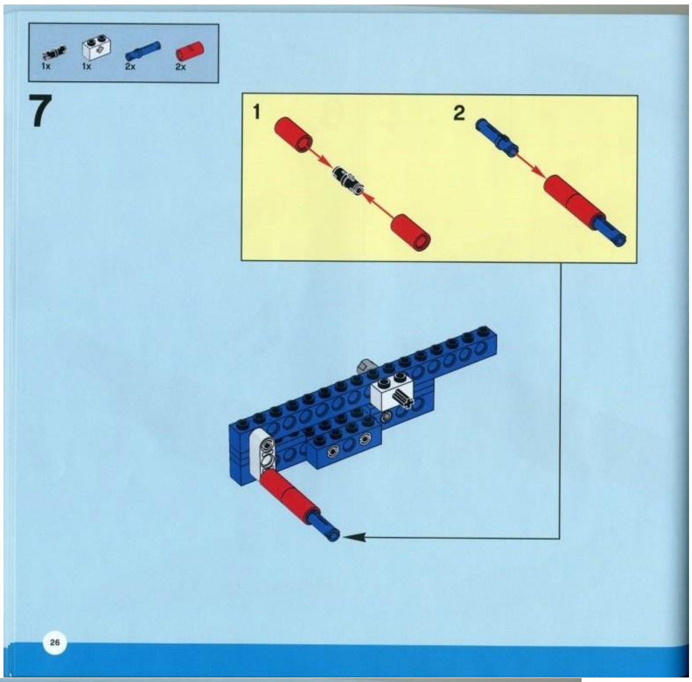


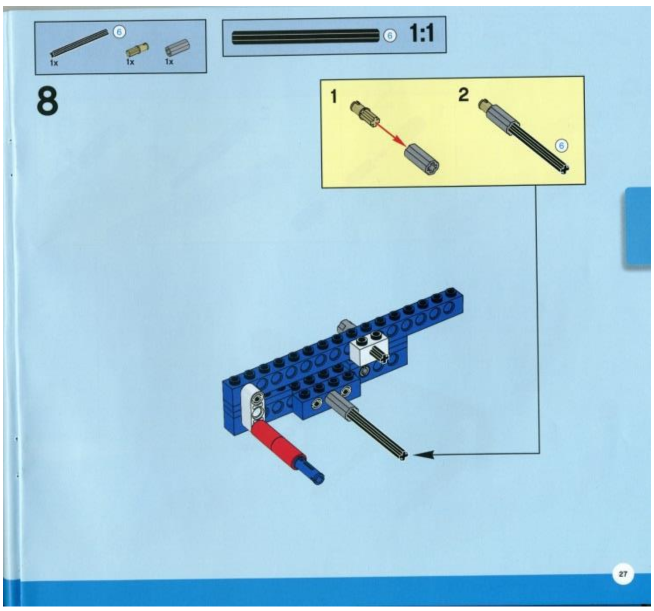
LEGO. Construction step 2. Wheels, cogwheel and engine.

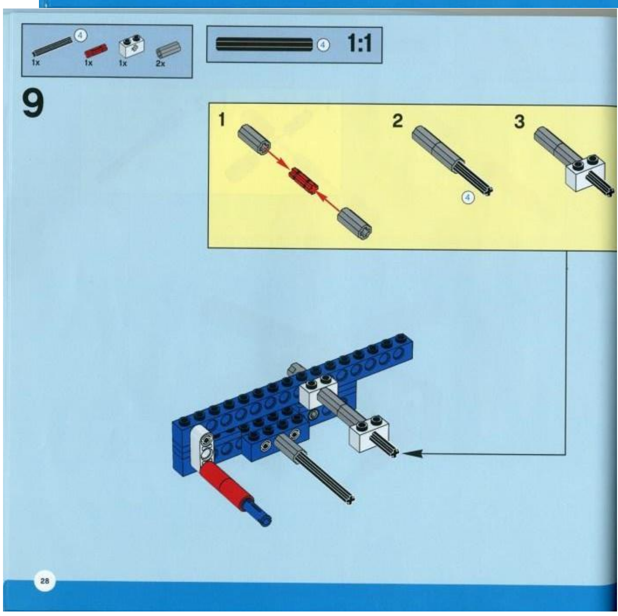


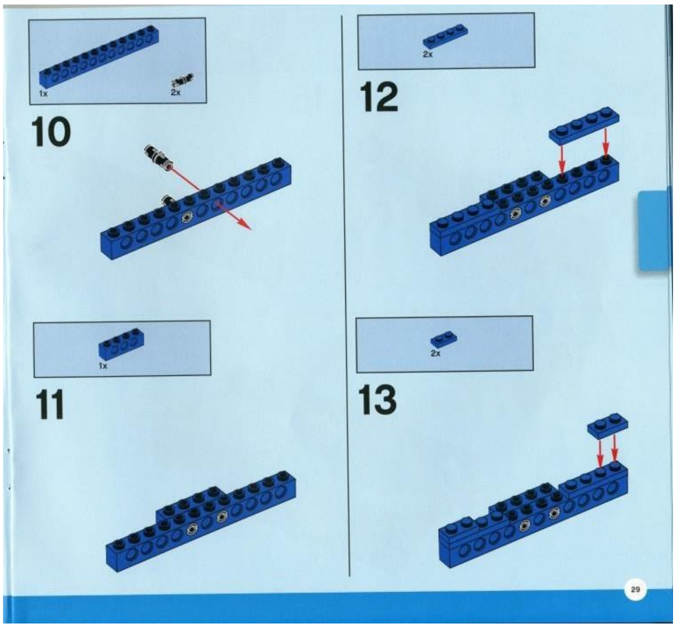








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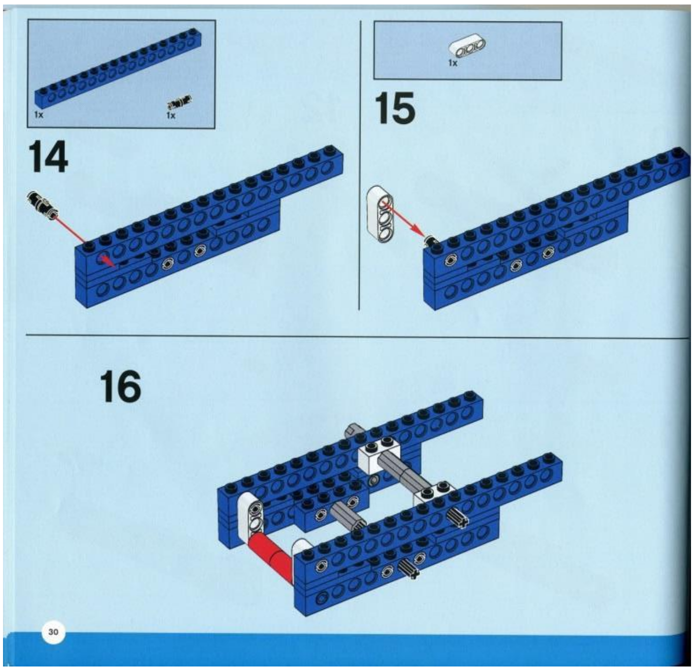
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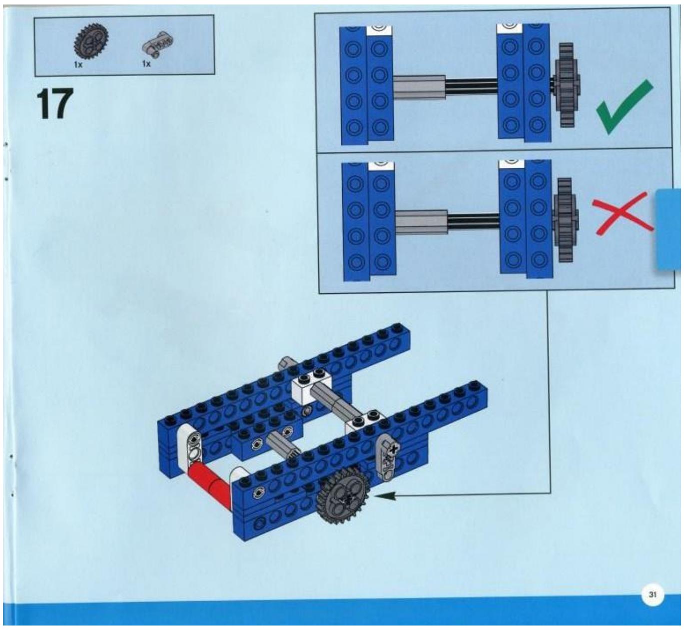
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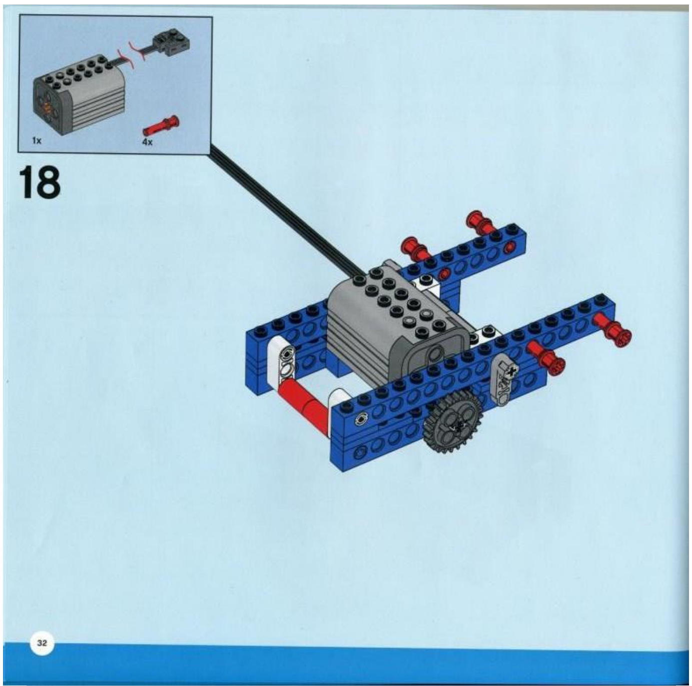
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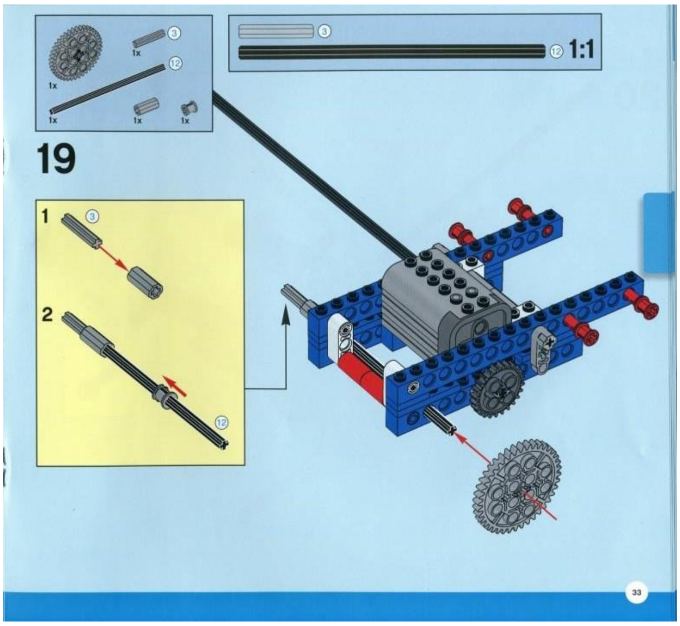
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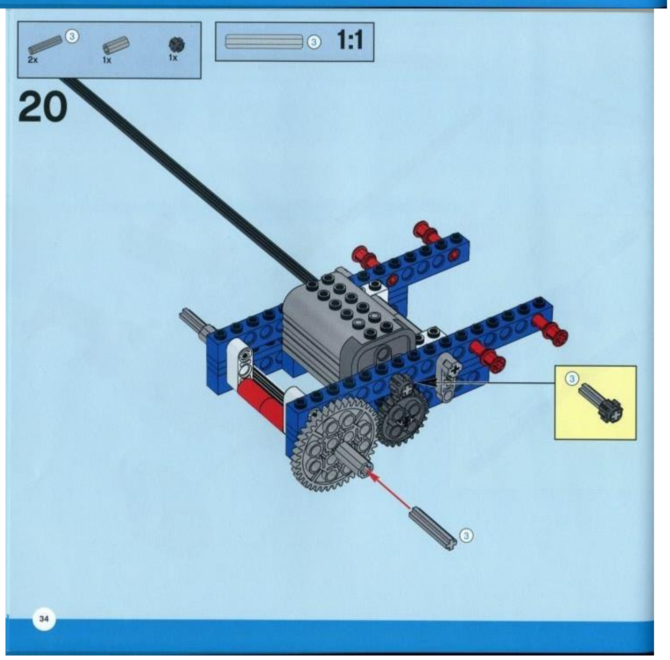
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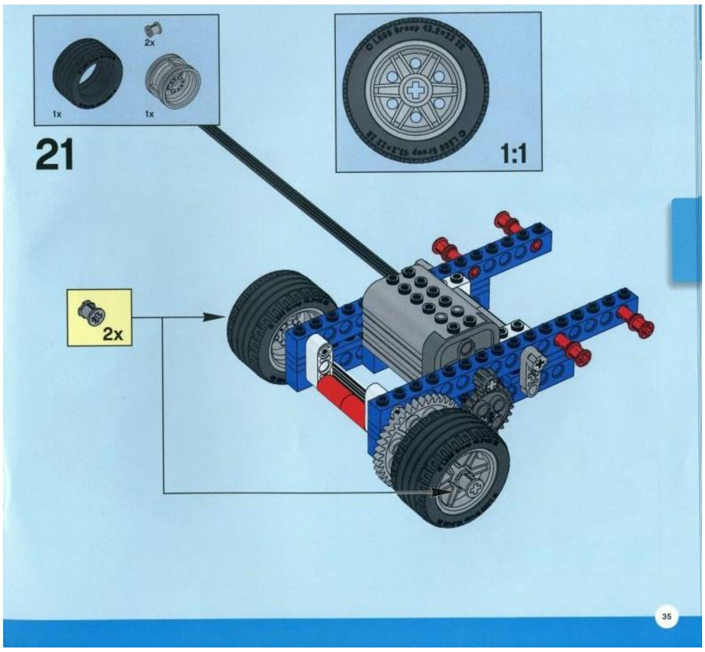

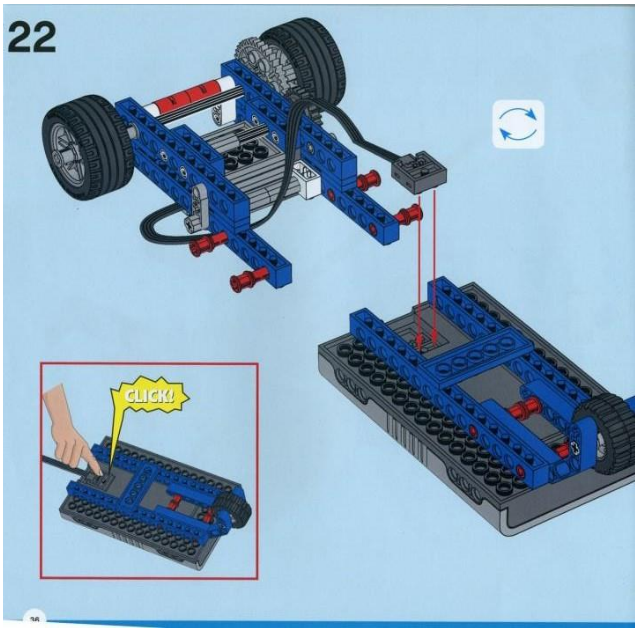

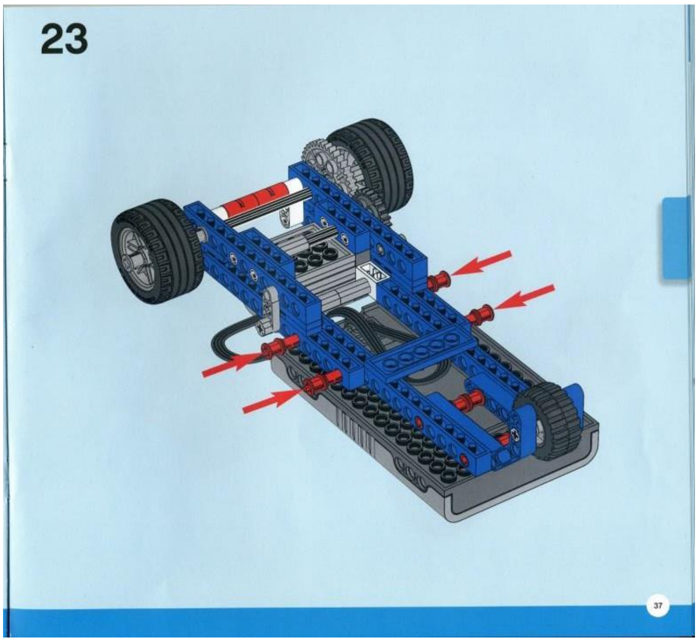

There is one more instruction for changing wheels and cogs to get another gear ratio.

Gear ratio

With a cogwheel that has 10 teeth, and which is connected to another cogwheel with 40 teeth, the gear ratio will be 4 to 1 or 1 to 4, depending on how they are put together. If the small cogwheel is placed on the engine and drives the large cogwheel, then we get low gear. The small cogwheel then rotates 4 times more than the large cogwheel.
If the engine is a human on a bike, it will be easier to pedal, but the bike will not get so far. It is practical when going uphill. We gain in force but lose in displacement by pedaling many times without getting so far.
If we place the large cogwheel on the engine instead, to let it drive the small cogwheel, then we get high gear instead. Then the large cogwheel spins four times less than the small cogwheel. As a biker, it means that we (as being the engine) can pedal quite slowly even though the wheels are spinning fast. This is practical when going down a slope. If we don't gear down when going up the slope it will be very heavy and it's not sure that our legs (that are the engines) will manage to drive the cogwheels.
A small electric motor that spins 10000 rpm (rotations per minute) is not very usable. An electric handmixer that spins 10000 rpm when we whip for example a cake mixture, can either cause a lot of splashing or it might not manage to drive the whisks when the mixture is getting thicker. Then it is better to gear down using cogwheels so that the whisks don't spin as many rotations but get more force instead. The engines on the solar cell Lego cars are also spinning too fast and therefore we provide cogwheels to place on the engine shaft.

Cogwheels of the LEGO solar cell car

In the first design according to the instruction, the car is geared down, i.e. it has a larger cogwheel on the axle. This means that it is more powerful, and it should be easier to drive up a hill, just like when we gear down our bike or car in an upward slope.
In the second design (p. 39-44 of the Lego drawing), the cogs are of the same size which means that the car should drive faster on an even surface but will not be as powerful going up a hill.
The small cogwheel on the motor axle that is connected to a larger cogwheel will make the electric motor's fast rotation to gear down and the car to go slower but become more powerful.

Gear ratio
With a gear ratio of 4 to 1, the engine shaft will spin 10000 rpm and the axle on the large cogwheel will spin 2500 rpm.
If the large cogwheel instead is placed on the engine shaft and drives the small cogwheel, the gear ratio will be 1 to 4, which will make the small cogwheel spin 40000 rpm.

Read more about natural sciences and technology in the book *Play and learn natural sciences and technology outdoors.*

The book was released in 2014 by Nynäshamn Nature School in cooperation with the Nature School in Lund. It contains more than 350 pages, of which 30 pages are copying material.

We wish that this book will inspire teachers to become curious about everyday phenomena, dare to catch the moments and to challenge themselves when it comes to natural sciences and technology, together with the children in preschool and preschool classes.

150 activities are presented in the book, where both children and teachers are challenged to different extent. Many activities are colloquial, caught in the moment. Other activities are staged, created learning situations. Most of the activities are possible to perform in other ways than described here; eventually it is the children, teachers, the situation, the gathered experience and the location that determine how the activities will be done.

The described activities are combined with several fact boxes describing the actual subjects and which the children will have the opportunity to experience. The fact boxes are divided in technology, physics, chemistry, biology and geoscience. The book can be used both for methodology and facts.

There are also some 30 pages of illustrated copy materials that can be used both as activity cards and as discussion and reflection materials.

The work with '*Play and learn natural sciences and technology outdoors'* started with a mindmap based on the quotations in **the Curriculum for the Preschool (Lpfö 98, rev 2010) and the main content of technology and the sciences subjects in the Curriculum for the Compulsory School (Lgr 11) for pupils of years 1-3**. The book addresses both preschool and preschool class but during the process it has shown to be useful also for children in grades 1-3.

Perhaps the book will work as a link between the preschool and school within these subjects and contribute to increased dialog and contact before the handover of the children the year that they turn 6 years old.

www.nynashamnsnaturskola.se

Nynäshamn Nature School provides **courses** based on the books in the 'Outdoor Learning'-series, see [here]().

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