Heating and Air Conditioning with Regard to Energy Saving

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Recommended year	*8 – 9.*
Time framework	*3 – 10 school lessons / hours*
Thematic block	*Heating and air conditioning with regard to energy saving*
Interdisciplinary relations	*Physics: Thermodynamics, Fluid mechanics* *Chemistry: exothermic reaction during combustion* *Mathematics: simple rule of three calculations, geometry, trigonometry, arithmetic average*

Theoretical introduction

Heating and air conditioning project with significant subfields presents the issue of practical examples and the target group and adequately simplified. to efficiently design the teaching not only to specific technical subjects, but across the board into other science subjects this chapter interdisciplinary overlap different school subjects. After the physical training is the issue of heating and heating relatively complicated and describable mathematically expressible complicated. However, heat loss calculations or designs complex heating systems and insulation are a mandatory part of any new project documentation for the construction of residential buildings. Specialized software helps the engineers with complex calculations. The resulting label building then describes how a given building energy-consuming, how much the owner will pay for water, electricity or heat.

Methodical part for teachers

Goal of the lesson:

- • Consolidate knowledge in the field of energy conversion, tie them with practical application.
- Adopt the correct measurement procedures and data processing.
- Create a new concepts and graphic symbols of the right of association.

Goal of the lesson:

Activity 1 - Measuring the temperature with a thermometer and electronic temperature sensors (15 min.)

Activity 2 - temperature measurement environments worksheet (15 min. + 15 min.)

Activity 3 - Thermal conductivity materials, worksheets (15 min. + 5 min.)

Activity 4 - Heat losses and insulation work sheet A, B (1 hr. + 3 hrs.)

Activity 5 - fluid flow in the heating system (10 min. + 20 min)

Activity 6 - Types of heating systems and radiators (10 min.)

Activity 7 - Transferring heat from the convection heaters (15 min.)

Activity 8 - Connect source heat radiators (15 min. + 5 min.)

Activity 9 - The heat source for heating households (15 min. + 10 min.)

Activity 10 - Production of hot combustion gas Worksheet (5 min. + 5 min.)

The project consists of the implementation of individual activities properly connected supplementary information for students and other extension tasks. These tasks are not only aimed at talented students, but serves generally as well as incentives for individual solutions and considerations. It is important when teaching each activity state, make sure that students understand the results and the establishment together with pupils evaluate. It is always necessary to adapt the activity of specific target groups and the current climate of a class or a particular educational program.

Introduction to the topic realized within 5 minutes guided motivational discussions on the topic of domestic heating systems, fuels, clean combustion (burning what can you not like.). The aim is to anchor and identify basic concepts, to build on the personal experience of pupils. Summarization of possible outcomes is to be found in the form of a student textbook.

Activity 1 - Measuring temperature with a thermometer and with electronic temperature sensors (15 min.)

Initial activity is focused on the reading scale and familiarity with the kinds of thermometers and temperature measurement method. Working with the thermometer is essential for the successful implementation of the other activities listed above. If we have more kinds of thermometers, we can make measurements with one type of thermometer and demonstrate its function. An alternative option consists in connecting the electronic temperature sensors, which are part of the pupils' laboratory systems like Pasco, Vernier like. Here it is also possible graphic processing of measured values. Evaluate compliance with the principles of correct measurements and the accuracy of the solved exercises (colored columns).

Activity 2 - temperature measurement environments worksheet (15 min. + 15 min.)

The basic measurement is measuring the temperature of the mixture of water and ice. Measurement of temperature of the boiling point is an additional exercise. Due to its relative hazard it can be shown also as a frontal experiment. Pupils have to memorize two important temperature points and acquire basic processing of measurement results. We evaluate the process and the accuracy of the results, where the answer to a supplementary question. Alternative variant consists in connecting the above-mentioned measurement systems or realization boiling temperature measurements through a pupil of the experiment (e.g. team of pupils).

Activity 3 - Thermal conductivity materials, worksheets (15 min. + 5 min.)

This sub-theme is introduced by the text of the pupil 2 images explaining the principle of heat transfer. If students with this principle and these concepts were not even aware of, we are using examples and graphics to indicate the issue. Otherwise, it will revise and consolidate previously learned knowledge. Pupils in this activity, particularly search and sort information. Sensory perception of subjective sensations of heat and cold, and describe the record. An alternative variant consists in the use of computer technology and the Internet. By default, pupils search for information in the tables, but the dates are widely available on the Internet. Pupils search by keyword of "thermal conductivity" or "thermal conductivity". Suitable is the involvement of the mobile devices with the Internet.

Activity 4 - Heat losses and insulation work sheet A, B (1 hr. + 3 hrs.)

Principal activity of the project consists largely of working with the insulating material, measurement and eventual bonding. It is advisable to carry out the activity in the group and how the construction Insulation box, so the actual measurement (separation of functions). These are the most relevant measured results. The actual measurement last ideally at least 15 or 20 minutes. Measurements performed best electronic sensors, but can be modified and used boxing and liquid thermometer. During measurement, the students continually write data to the table and in the chart! An alternative option is the electronic processing of results using a spreadsheet (Excel, Calc ...), online measurement using sensors pupil measurement system or modifying the measurement variations: different amounts of jars with hot water, changing external temperature (room outside), changing the insulation thickness, etc. The insulation box serves as a calorimeter, which can make further experiments and calculations. E.g. heat losses, heat transfer coefficient Calorimetric equation.

Activity 5- fluid flow in the heating system (10 min. + 20 min)

Activity demonstrators called the passive or the gravity heating system. The main method of implementation activity is the observation of physical phenomena. We also attempt to demonstrate frontally and using the conveniently placed overhead projector and subsequent projections, or may result show groups individually. Alternative variant requires lamps and bulbs in a group and is dependent on the particular job class.

Activity 6- types of heating system radiators (10 min.)

Extension activity familiarizes students with mostly different types of radiators. This explains principles and activates the knowledge of pupils for the next activity. 7. We complement interpretation projections of matching images placed radiators and floor heating. Suitable also aids in the form of parts of heating systems (valves, thermostats, etc.).

Activity 7- transfer of heat from the radiator air flow (15 min.)

Pupils work with a thermometer and measure the temperature in different parts of the room, according to the figure no. 3. Verify the theoretical assumption of rising warm air above the radiator. The activity may take place in an environment in the classroom and at home in the form of a separate homework. We evaluate in particular the presence of relevant data and the proper units. Activity is no problem feasible only if a functional heating system (i.e., when drowning, cold days) for the summer months we can observe mass airflow over the hotplate cookers, near the radiant panel heaters or above (frontal attempt). We measure a higher temperature at higher altitudes room although the heating does not work. Understanding the heat transfer is important for proper placement of radiators in space and efficient heating.

Activity 8 - Connect source heat radiators (15 min. + 5 min.)

On the attached plan residential units pupils design of the heating system verifies knowledge and repeats selected elements of graphic communications. Activity is conceived as homework for pupils and accordingly the rate. Alternative variant realize, through interactive whiteboard. The interactive program we transfer plan apartment and utility program plots the required information (radiators, pipes, pump, etc.) work with an interactive whiteboard can be used to control solution or just as a motivation.

Activity 9- heat source for heating households (15 min. + 10 min.)

Activity focused on search and information processing and conversion. Students get an overview of the calorific value of individual fuels and their approximate cost. For the calculations, we've simplified the activity, eg. Heat of combustion is equivalent calorific

value, but the values are similar. We evaluate particular calculation accuracy and comprehensiveness and relevance of the information found on the Internet or in tables. Part of the activity is an alternative option in the form of a simple experiment - demonstration of the principle of electric heating. This option requires utilities described, however, can be realized in a minimalist option as the student experiment - flat battery + a bulb = simple electric circuit.

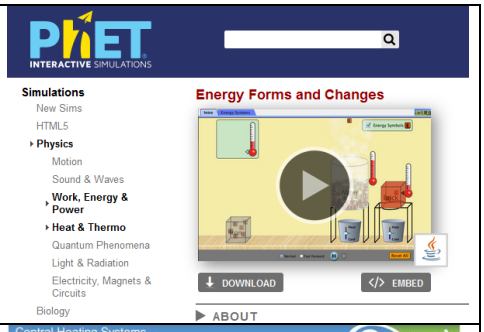
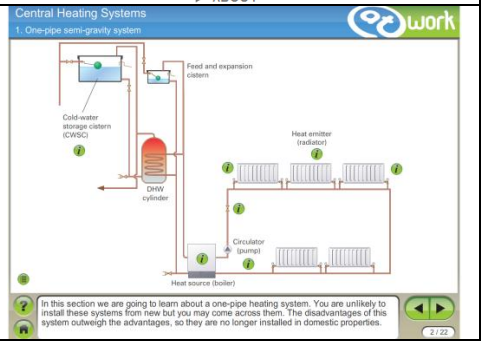
Activity 10 - Production of hot combustion gas Worksheet (5 min. + 5 min.)

Through this activity students identify the various parts of the boiler. They realize the relative simplicity of design solutions along with symbols indicative of selected parts and boiler components. Students opt for assigning the line to the corresponding parts of the image. An alternative option is to implement activities using interactive whiteboards. We evaluate the accuracy of the assignment.

Activity 11 - Energy conversion and fuel combustion (15 min + 10 min.)

Interdisciplinary activities overlap mainly in mathematics, physics and chemistry. Pupils realize energy intensity of hot water, and remind the ignition process is as converting chemical energy into heat. Attempt candle is trivial and therefore suitable as homework. The pupils perceive the potential risk of toxic fumes can minimize the danger. An alternate variation involves the measurement of combustion products by using the oxygen sensor, carbon dioxide and carbon monoxide

Supporting interactive materials

Phet – interactive simulations Interactive animation demo heat transfer - virtual visual measurements *https://phet.colorado.edu/en/simulation/legacy/energy-forms-and-changes*	
Central heating systems Interesting animation with a number of schemes of heating systems. There's more information to the components or demonstration movement of the heating medium *http://www.pearsonschoolsandfecolleges.co.uk/demos/PlumbingInteractive/shell.html*	

Learning Text for Pupils

Why do we have to heat in winter and cool in summer? In the summer we need to be out in just a shirt. It is because of the temperature of air moving above 20 ° C and the amount of sunlight, which is directly exposed to our object. Ambient air is heated from the surface due to the infrared component of solar radiation. In summer the sun shines longer than in winter. Furthermore, when the sun is above the horizon and its rays strike the earth's surface almost vertically and the same area of the Earth's surface and solar irradiation more. In winter, when the day is shorter and the sun is at noon just low on the horizon, and the air temperature decreases during the long night of the earth's surface rapidly cools to temperatures even far below 0° C.

In the winter it would have been only a T-shirt winter, and therefore we wear "warm" winter jacket. But even the best winter jacket does not heat itself. Only our body heated to about 37 ° C, it is thermally insulated and prevents the cooling and thus our colds. The houses in which we live, have walls made of bricks or concrete, and in the winter they can so easily dress extra sweater or winter jacket. When the outside air temperature drops below 10 ° C, walls and indoor air home also slowly cool us inside the house is cold and you need to turn on the heating. When you turn on the heating in the house, we heat the air inside and thus the walls inside the house, while the ambient air outside the outer wall of the house still cools. It's as if we were outside in the winter without a sweater and winter jackets and still drank hot tea.

Often each other concepts confuse temperature and heat. Temperature is a property of the object, which can be directly measured with a thermometer. Its commonly used unit is the degree Celsius. Call it a better temperature sensor or temperature sensor.

Information– In physics, the more frequently used temperature unit 1 Kelvin. It is true that the change in temperature of one Kelvin is equal to the change in temperature of one degree Celsius, making it possible to perform most calculations in degrees Celsius.

In contrast, the heat in physics indicates the amount of heat energy, which one element from another object. The unit of heat and thermal energy is the Joule. Thermal energy, which substance has adopted or handed over to another object, depends on the temperature of the object, the object weight monitored and heat capacity of the materials from which the object is made. Thermal energy Q is then obtained by multiplying the weight of the object m, specific heat c and the temperature differential between the object and the surroundings (t_2 - t_1) according to the formula

$$Q = m \cdot c \cdot (t_2 - t_1)$$

For example, water of the specific heat capacity of about 4200 $J \cdot Kg^{-1} \cdot K^{-1}$ (joules per kilogram per Kelvin) at a weight of 1 kg and a temperature of the object t2 higher than the ambient temperature T1 of 10 ° C has a thermal energy of 42 kJ relative to ambient temperature t_1.

Received or delivered heat can be determined by the so-called calorimeter. Always follow the process of mutual transfer of heat between at least two bodies. After stabilizing the temperature of objects in the system has a system of bodies in the same calorimeter temperature.

Bulb icon – How quickly one object transmits the heat energy to another object, describes the physical quantity named thermal performance. Performance always says what energy was transferred for some time. The shorter this time is, the higher the performance. Watt is a unit of power ($[P] = W = J \cdot s^{-1}$) or Joule per second.

Information icon– If 1 kg of water from the previous example warmer than his surroundings 10° C passed all of the thermal energy in the neighborhood for 1,000 seconds (about 17 minutes), would heat output of this process, 24 W (watts). If balancing the temperature and heat transfer, however, lasted only 10 seconds, it would have thermal output of 4.2 kW (kilowatts).

Thermal energy that passes through the wall of a house in the neighborhood, it says heat loss. Energy is never lost, however. Here applies the law of conservation of energy. House needlessly heats outdoor air and from our perspective as warmth come. Heating the house need just balancing the heat loss. In doing so, we want heating in every room to add exactly as much heat energy as it passes through the wall of the house out. This depends on the temperature difference inside the room and outside air temperatures, the thickness of the peripheral wall and on its surface. Knowing the surface of the outer walls of the house of square meters of the material and thickness of the walls of the house, we can use simple calculations to estimate the heat loss of the whole house and propose properly heat the building. Order at a specific outdoor temperature to maintain the desired temperature inside the house, we have to exercise either continuously regulate heating, or heating is constantly on and off. Thermal power going trough external walls of the house means unnecessary heating the outdoor air which mean, we raise the heat output of heating without any use.

In the summer the house warm right sunlight and warm the surrounding air and the temperature inside some rooms can rise as emotionally unbearable limit, when we turn on the air conditioning. Air unlike heating conversely heat the room air drawn thus reducing the air temperature to less than 25 ° C. Even with unwanted increase in room temperature apply the law of conservation of energy. When removing heat the room air conditioning must actually have more heat so hot outside air.

I probably already figured that if all the houses properly "dressed" in the thermal insulation, actually, we do not have at home or even to heat and cool so we could save every winter a lot of money. But such a "dress" the house is worth something. For many people it is easier to press the heating or air conditioning and more on the stake. It is therefore up to you, the young generation that wasted energy and wasted no heat build modern houses in the winter unnecessarily not heated outdoor air. They are called low-energy houses. To maintain a comfortable temperature in a house in the winter we do not still actively supplying thermal energy and heating in the largest frost is enough to heat a very small thermal power. There are even so-called passive houses with such a perfect thermal insulation; they can stay warm completely without heating.

Activity 1- Temperature measurement electronic thermometer and temperature sensors

Information icon - The temperature measurement serves different types of thermometers. The simplest are already historical thermometer liquid based on the principle of thermal volumetric expansion of the liquid, such as mercury or alcohol thermometer. Due to increase in temperature increases the volume of liquid in the flask bulb. Liquid column continues a thin tube with scale and thus the length of the liquid column in the tube shows the temperature of the liquid

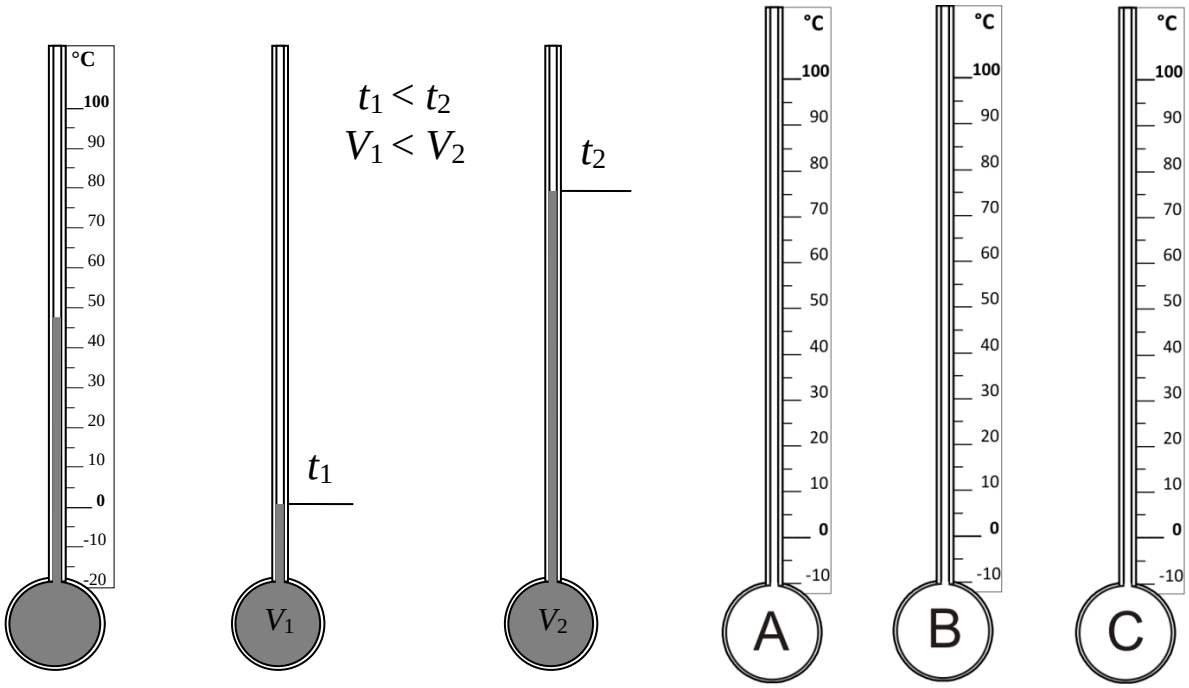


Figure 1 – The function of liquid thermometer. As temperature increases the volume of liquid and thus the height of the column in the tube (left)

Exercise icon– For thermometers A, B and C in FIG. 1 to color the liquid column to a height corresponding to a = 30 ° C, B = -5ºC, C = -47ºC.

Exercise icon– Measure the room air temperature of different types of thermometers and compare among themselves, while the measured temperature value. Place close together various thermometers. Do not hold, while none of the thermometers in the hand because your object has a higher temperature than the surrounding air and the thermometer so hot. Please prefer to lay the thermometers on a table or hang on the wall beside.

Question Mark icon - match the air temperature measured by different thermometers? How do you know which one actually thermometers measure accurately?

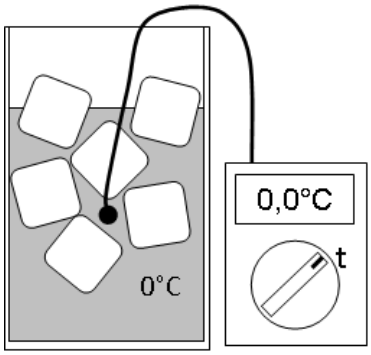
Activity 2 Worksheet

Measuring the ambient temperature

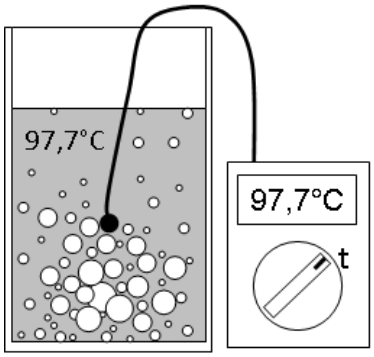
Bulb icon - To know what thermometer scale displays, and if measured correctly, we tested a temperature sensor to measure the temperature of the object with clearly defined temperature. He did this by the Swedish physicist Anders Celsius (1701-1744), after whom it is named for us to use the Celsius temperature scale. Like him, we will attempt to measure the temperature of boiling water and melting ice.

Remember icon - test thermometer must be suitable for liquid immersion and "endure" boiling point. For electronic temperature sensors themselves is fulfilled. Not always but it also applies to other electronic components built into a plastic box measuring device. Measuring device, therefore, never immerse completely in water.

A: Temperature of ice melting



B: Temperature of water boiling



A: Measuring the temperature of melting ice

Just before measuring, mix in a larger laboratory beaker of ice cubes with cold water and leave at least 5 minutes to settle their temperature. Melting the mixture of ice and water, according to the definition of the Celsius temperature scale 0°C. It is the melting point of ice. When now to the mixture immersed thermometer or electronic temperature sensor, then after a while the equalization of temperatures between the temperature sensor and a mixture of ice and water. Measurement Repeat 3 times for each type of thermometer.

B: Measuring the temperature of water boiling

Work under the supervision of a teacher! Observe the instructions!

Fill a kettle about halfway with water and place the thermometer to measure the temperature of liquids and kettle on. Follow the same time, how it behaves in the water kettle with increasing temperature, which we see as a figure on the Meter connected to a temperature sensor placed in heated water. Boiling occurs when in the volume of water begin to appear large bubbles.

	Thermometer type Electronic, liquid, bi-metal…	Temperature *t* measured in °C			Arithmetic mean
		Measurement Nr.1	Measurement Nr.2	Measurement Nr.3	
1A					
2A					
3B					
4B					

Information icon – Be careful that the thermometer found roughly in the middle of the beaker and does not touch the outer wall of the beaker that is heated ambient air.

Question mark icon – Verify the value of the boiling temperature of water measured by the temperature sensor also in mathematics and physics tables and on the Internet. Why is the temperature of boiling water not exactly 100° C? Explain it.

Learning Text for Pupils, Part 2

There are three different modes of heat transfer in cloth. For solids, the major heat conduction. For liquids and gases is strongly applied also convective heat transfer and even without the presence of the substance is possible third method of heat transfer - heat transfer by infrared heat radiation. In practice, there is a combination of all three modes of heat transfer between the bodies.

In order to transmit heat by conduction, the object must be in close contact. Then the one object transmits thermal energy to the other. Or one object can take away heat from the other object. In order to transmit the thermal energy, the object must be always different temperatures. When the temperature of both bodies aligned, heat transfer ceases. How easily the object of a substance is heated or cooled, depending upon its material composition and structure. High density housing also conducts heat well. Conversely, a object of material with low density and structure containing air enclosed in the small cavities conduct heat very slowly. Porous materials containing many tiny air bubbles because they have good thermal insulation properties. Ability of a material to conduct heat described constant-called specific heat transfer coefficient λ given in watts per meter per Kelvin ($W \cdot m^{-1} \cdot K^{-1}$·or $W \cdot m^{-1} \cdot deg^{-1}$).

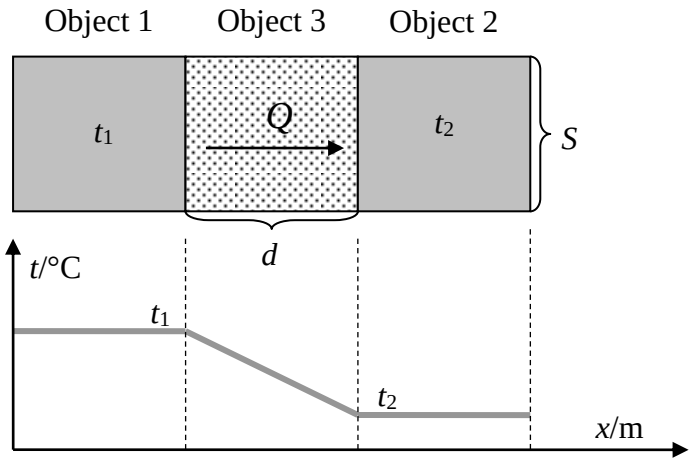


Fig. 2 - Schematic representation of the heat conduction

For Temperatures $t_1 > t_2$ the temperature difference change with distance d according to

$$\frac{(t_2 - t_1)}{d}.$$

Transmitted heat Q in time τ, with surface S is given by

$$Q = \frac{\lambda \cdot \tau \cdot S \cdot (t_2 - t_1)}{d}.$$

and the trannsmitted power is

$$P = \frac{\lambda \cdot S \cdot (t_2 - t_1)}{d}.$$

When convective heat transfer happens, heated air or liquid in a large cavity rises and cold air sinks down the contrary (remember the hot air balloon). If the cavity is heated on one side and

cooled on the other, creates a constant flow of air or fluid which transfers heat from one object to another.

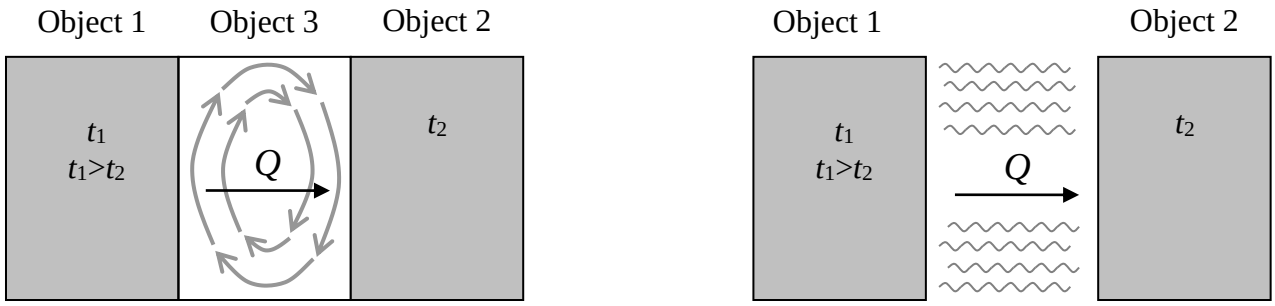


Fig. 3 - Left convective heat transfer of gas or liquid and to the right heat transfer infrared thermal radiation

Activity 3– Thermal conductivity worksheet

Exercise –Touch with the whole palm of the hand surface of the bodies made of different materials having the same pulsation. Solid surface temperature measurements verify the temperature sensor. The test materials should have a lower temperature than the object temperature, conveniently room temperature. Sense when touched by hand if the object is made from different materials, seem to be cold to the touch or appears to be warm. Write the results down.

Material	Ranking from the coldest to the warmest material	Thermal conductivity coefficient λ in watts per meter per Kelvin	Material ranking of the heat insulating properties from low to high
wood			
brick			
concrete			
tiles			
glass			
steel			
aluminium			
PVC linoleum			
carpet			
Styrofoam			

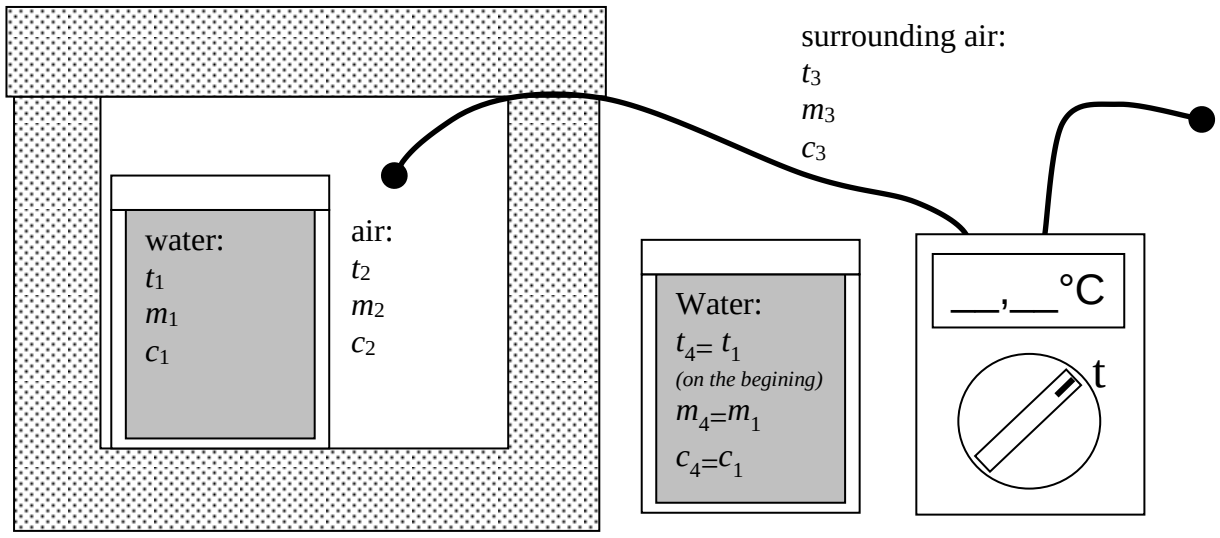
Exercise icon - Find in the mathematical and physical tables of materials or on the Internet materials with the best thermal insulating properties, add them to the table and sort by ascending thermal conductivity. What material came out as the best thermal insulator?

Information icon - What is the thermal conductivity increases, the material conducts heat better. Materials that conduct heat better are poor thermal insulators.

Question Mark icon- Put into hot tea metal spoon and a piece as long skewers. Grab both items and see which conducts heat better. What material has better thermal conductivity? What is a better thermal insulator?

Activity 4 – Thermal lost and thermal insulation – Worksheet A

Exercise–For this experiment, produce simple air calorimeter made of polystyrene foam. Measuring box model of the calorimeter is insulated house. As a bearing outer shell box can be used for example cardboard box from plain paper (plan 22 x 31 cm, height 25 cm) into which successively insert accurately cut expanded polystyrene boards of thickness 5-10 cm. Place the box in the school temperature sensor measuring system (Pasco, Vernier et al.). According to the needs you have to do one of the walls of the box pierced a small hole to steer the measuring cable, temperature sensor. Lid boxes Production from Styrofoam plates and lids cardboard boxes. Box before attempting tightly in a room where the room temperature.



For heating the air inside the house - thermal insulating box at higher than room temperature can be used sealable glass such as baby food, or jam-filled with hot water at 60° C. At higher temperatures had a risk of scalding. Suffice and hot tap water temperature to 40° C. The greater the mass of water in a glass box in place, the longer it will last attempt. The same glass with the same amount of water at the same temperature, leave and outside the box.

Follow the variation in air temperature inside the box by a temperature sensor located inside the house.

Measure also the ambient air temperature <u>outside</u> the thermal insulation box. Both temperatures along with the time course of the experiment record in the attached table

Exercise– Draw a graph of temperature inside the box at the time.

Question mark icon - At the beginning of the experiment, water temperature t_1 and t_4 equaled. What is the temperature of the water that was in the isolation box and the water that was beyond him? Why is the air in insulating box warmer?

Bulb icon - Model air conditioning. In the hot summer, instead of a hot object, you can use cold water in a glass chilled with ice. Place the herm isolating box into a warm environment and monitor using temperature sensors timing of air temperature increase inside the box. This will create a simple model of an air-conditioned house.

Activity 4 - Worksheet for heat losses and heat insulation in the model house

Initial temperature in both glasses _____°C.

Time τ in minutes	Time τ in seconds (1 min. = 60 s)	Temperature inside the box t_2 in °C	Temperature outside the box t_3 in °C	Comment
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
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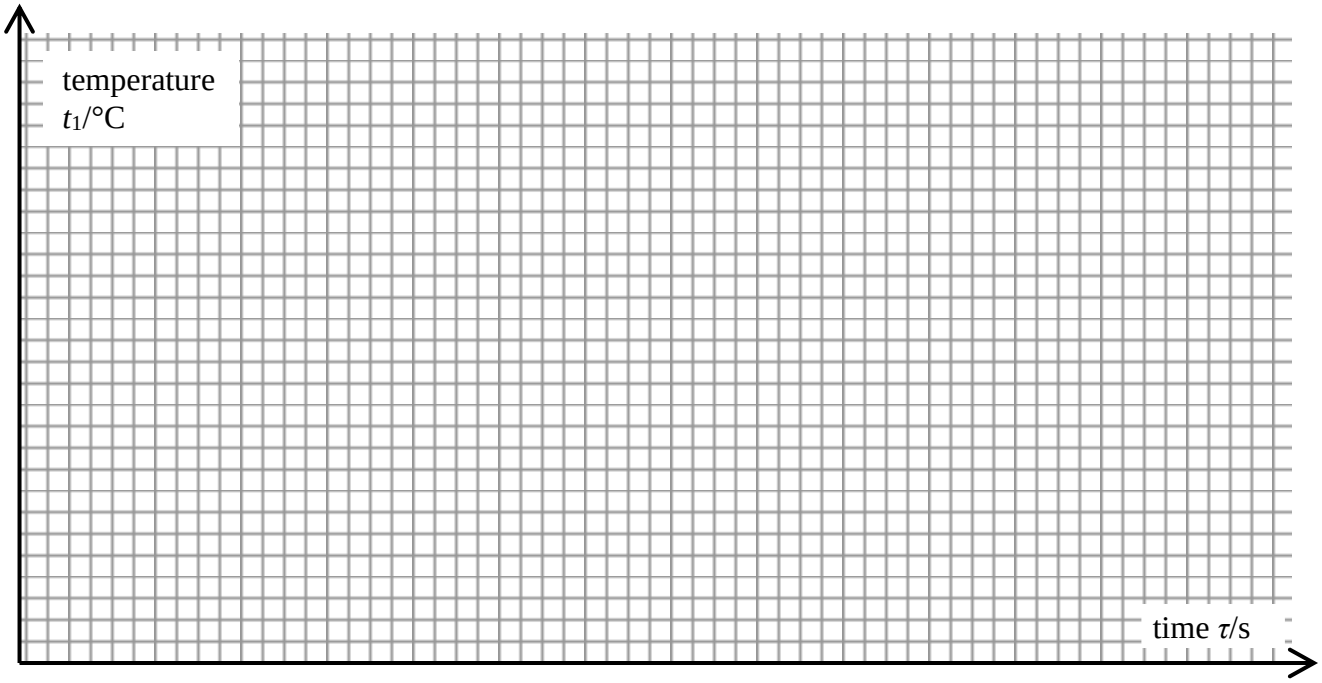
20				

Final temperature of water in a glass in the thermobox _____°C.

Final temperature of water in a glass outside the thermobox _____°C.



Information- lay out a time axis of 1 cm. 1 cm will then be equal to 60 seconds.

Activity 5 - Fluid flow in a heating system

In the past for heating the mostly so-called passive or gravity system of circulation of heating water have been used. The heated water a certain weight has a larger volume than cold water. This means that has a lower density, it acts on the buoyant force, and in the container rises. Cold water is compared to hot water higher relative density and therefore in the container falls down. Consequently arises in large containers or closed heating circuit liquid flow. It happens even in a pot on the stove.

Exercise - Observe the flow of water in a glass beaker of fireproof (at least 500 ml) or a tea made from borosilicate glass (ie. Pyrex). Warm the beaker with a Bunsen burner on one side over the diffusing grid to burst. Regulate the flame so that the water in the beaker begun to cook. You can also use an electric hot plate. It is important to heat the beaker from one side and on the other hand, let it cool ambient air. The flow of water in a beaker can be easily illustrated by successive dropwise addition of water dyed with food coloring or adding fiber wadding. Flow can also represent light. Shines through a beaker with overhead projector and watch the wall pattern caused by the flow of water in a beaker.

Modern heating systems are used for water supply, much lower water temperature and small diameter pipes. Water flow in thin tubes is due to the friction of water on their walls and slower gravity system already sufficient to transfer hot water to the radiator quickly enough. Therefore it is necessary to encourage the circulation of water in the heating system of an electric pump.

Question mark icon - What is the connection speed of heating water and the temperature difference at the inlet and outlet of the radiator? Explain it.

Activity 6 Types of heating system radiators

Question mark icon - What is your question mark-home or school type of heating and radiators? Recognize the different types of help following text.

The total transferred heat output of the heater to the room depends on the temperature difference between inlet and outlet of heating water and the radiator size. Small radiator will thus be at the same temperature of their surface than a less heat, but larger radiator. To forward the same to heat the room, he would be a small radiator very hot; a large radiator may be less hot. The heating elements can transmit heat to the room in two ways. The main component of the flow, which rises above the radiator heated air from underneath the radiator sucks air cool. A smaller part of the heat radiator radiates to the room as infrared radiation.

Today several types of heating are being used. Plate radiators are made of one or two large plates-flow with hot water. Each plate was made by welding two sheets around the periphery. Sectional radiators are similar plate made from welded steel plate or cast gray iron into a hollow mold. The resulting radiator is assembled from individual small cells by screwing them together. Radiators warm due to heat transfer by radiation and convection of hot air.

The third type of heating elements is hot air heating convectors for low temperature, which prevails convective heat transfer. They are made from tubes which are pressed fine aluminum fins that conduct heat well. Between the lamellae flows air that transfers heat into the room almost exclusively by convection. The last fourth type of heating for low temperature is the under floor heating. Water heating systems is hidden in the entire floor area, the pipeline has a large length and thus the contact area through which heat is transferred to the guidance of flooring material. Heated floor then heated ambient air through convective heat transfer.

Activity 7 - Transfer of heat from the radiator by convection

Exercise - Follow the flow of hot air above the radiator and the cooling on the window using illuminating dust particles or water mist from a spray bottle of water for retting flowers. *Information icon* - To illustrate airflow can also use individual fibers of cotton. Hot air from the radiator flowing upwardly entrained fine fibers or droplets of water and those with it move in the direction of airflow. In the vicinity of the cold surface of the window glass, the air in the room is cooled. The fibers will entrain again.

Question mark icon - Which way air flows over a radiator? Which direction near the window panes? Draw the picture. How do the air flow in the rest of the room?

Exercise - Measure the temperature of the air near the floor and the air temperature at the ceiling and at a height of about 1.5 meters above the floor. Turn off the heat and leave to cool radiator. Attempt and repeat. Enter the measured temperature in Figure 3. Plot the airflow in the room without switching on the heating system.

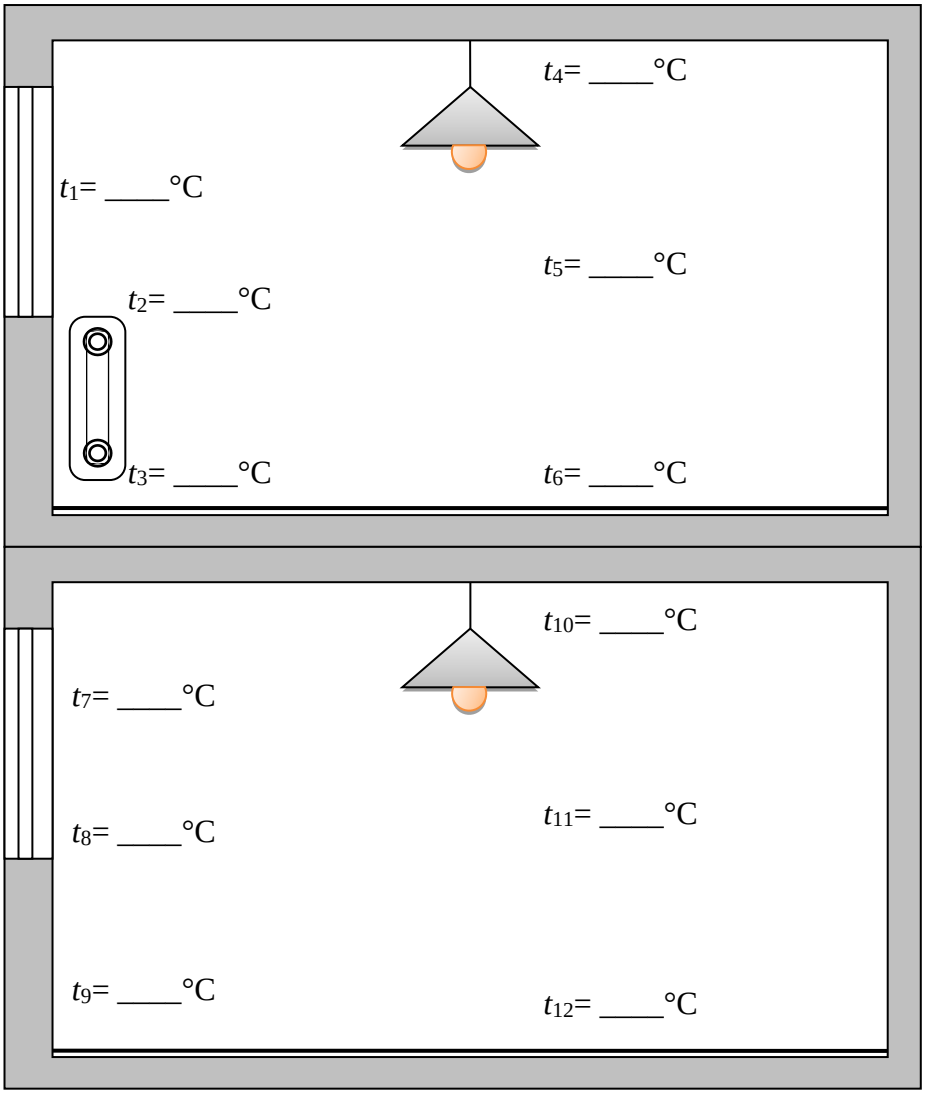


Fig. 3 - Diagram of a heated room (top) and an unheated room (below) for drawing the airflow.

Question mark icon - Why are radiators mostly placed under the window? Why should the radiator not be covered by curtains?

Activity 8 - Connect the heat source with radiators

Draw the floor plan apartment in a gas boiler as a heat source, radiators and their connection to the heating system using a two-pipe heating water distribution system. Draw red piping hot water from the boiler to the radiators, blue lines cold water from the radiators back to the boiler. The circuit must be closed. You can choose from seven different sized panel radiators for different sized greasiness in the apartment. Remember that gas boiler needs a flue to the chimney or on the facade. Draw a chimney according to the boiler location. Mutually discuss their proposals. What affects the choice of the size of the radiator and its location?

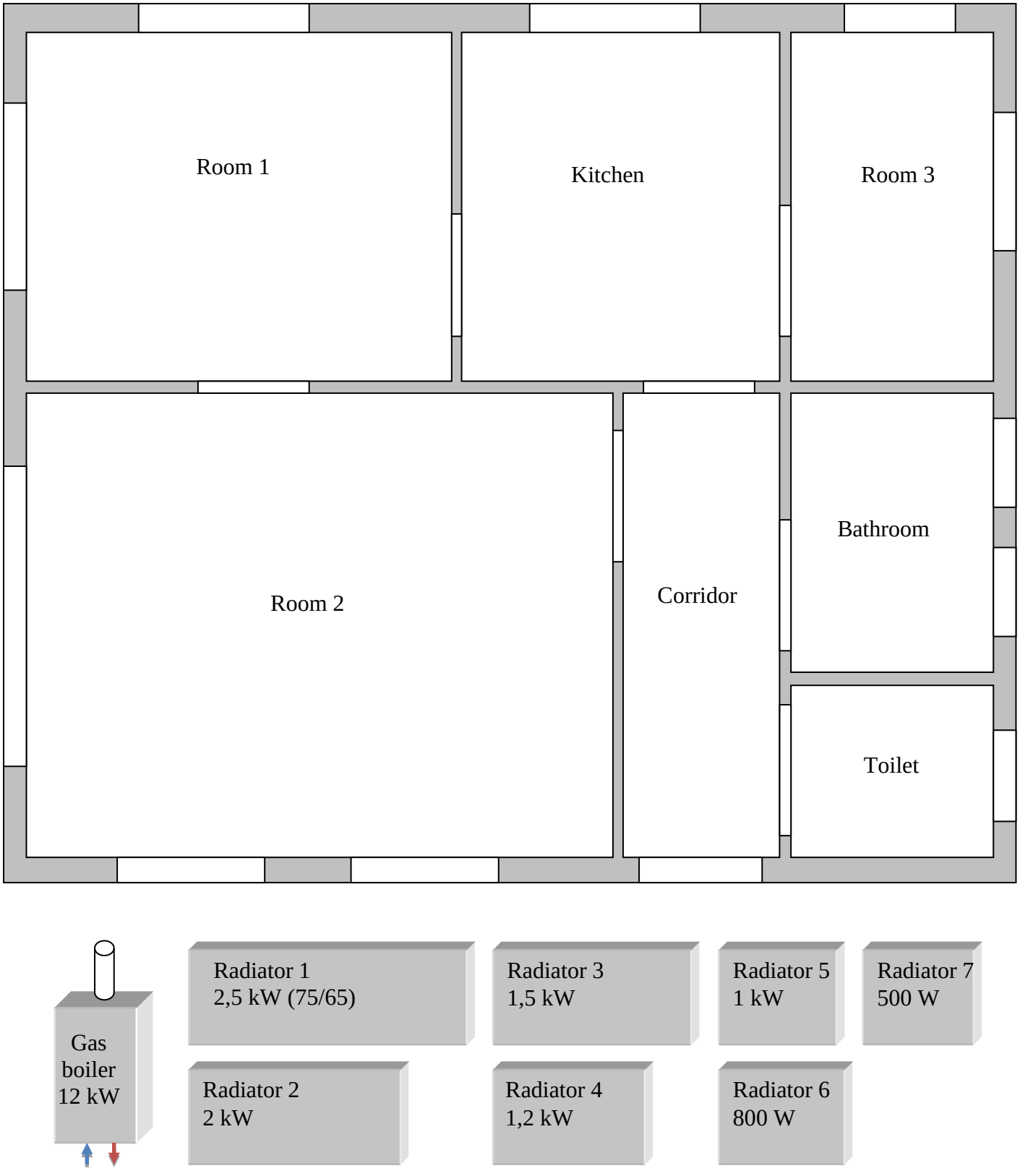


Fig. 4 – A plan of an apartment with individual rooms, heat source and heaters for the heating

Activity 9 - The heat source for heating the household

Exercise - Compare the prices of fuels with regard to their calorific value. Fill up missing data, which can be found on the Internet. Count prices for one MJ and one kWh.

Fuel	Combustion heat (calorific value)	price for unit	price for MJ in CZK	price for kWh v CZK*
Natural gas (1 m^3)	37,82 MJ/m^3	15,75 Kč	0,42 Kč	1,51 Kč
Black coal (1 kg)		5,5 Kč		
dry oak wood (1 kg)		1,05 Kč		
dry pine wood (1 kg)		1,27 Kč		
wood pellets (1 kg)		6 Kč		
Electricity (1 kWh)		3,50 Kč		3,50 Kč

* 1 MJ (megajoule) = 0,278 KWh (kilowatthour)

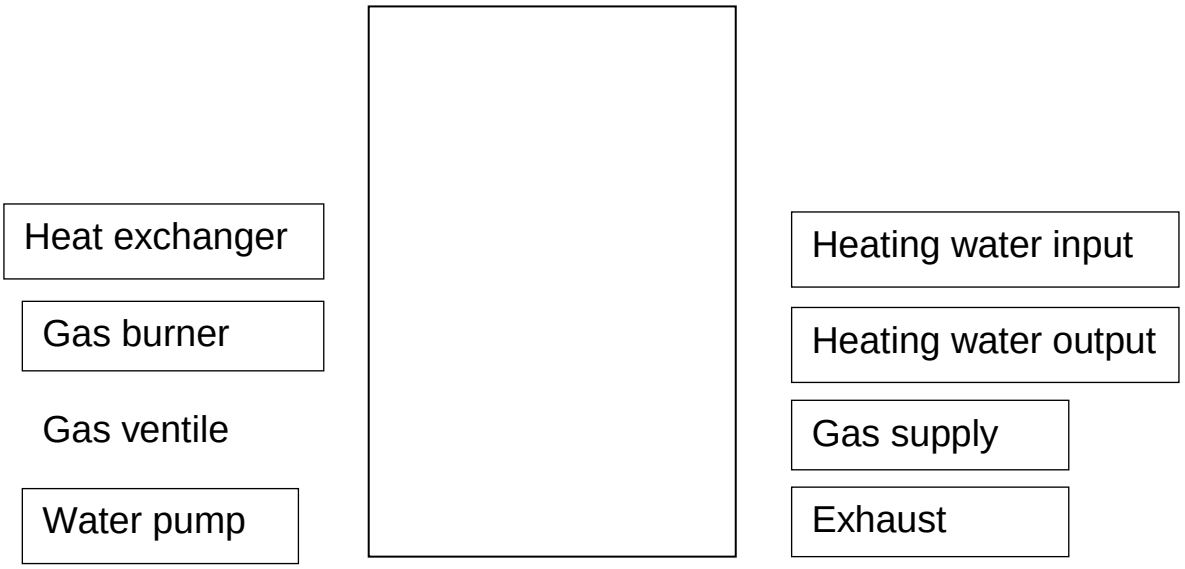
Question mark icon – The combustion heat (calorific value) indicates how much energy from the material released its complete combustion. Is combustion is always perfect? What is this efficiency?

Exercise– Attempting a bulb as heat source. Create a simple electric heater with the help consisting of conventional 60W bulb and a controllable voltage source of 0-20 V. What is the thermal efficiency of the filament bulbs? What is at stake bulbs three different modes of heat transfer around - conduction, convection and radiation? Observe the color dependence on the filament voltage across the lamp.

Information icon – Heating electricity is based on the consequences of Ohm's law, when a conductor with high resistivity current passage heats. For example, they use low-temperature oil radiators, in which the resistance wire wrapped around the ceramic object stored in Sectional radiators filled with oil. For high temperature electric heaters hot wire transfers heat directly to the surrounding air flow. Infrared heaters, such as a light bulb and the heat source with a very high temperature and the heat transmitted to other places predominantly radiation. The efficacy of low temperature heating electricity is almost 100% as the current passage is formed only heat.

Activity 10 – Heat production by gas combustion

Exercise icon– Link the parts of a gas boiler an the picture with correct terms



Information icon - The heat output of the heat source operating on the principle of combustion of fossil fuels can be adjusted only within a certain range of the chemical properties and the amount of combustion gas or a solid fuel such as coal. For smaller apartment or small house sufficient heat output heating sources ranging from about 4 to 12 kW. Power 24 kW longer sufficient for heating as well as a large family with poor thermal insulation or small apartment building.

Question Mark icon - What is the effectiveness of different types of boilers? Search on the internet websites of manufacturers and online catalogs of their products. Discuss with classmates, whether it pays to replace old boiler with a new one, and for how many years the investment returns.

Activity 11 - Energy conversion and combustion

Exercise icon–What heat energy is required to heat 50 liters of water of 10° C to 40° C? The amount of hot water represents about consumption of hot water per man per day. Which thermal power is required to heat 50 liters of water for 30 minutes, 15 minutes, 5 minutes and 1 minute? How much it costs to heat enough water every day?

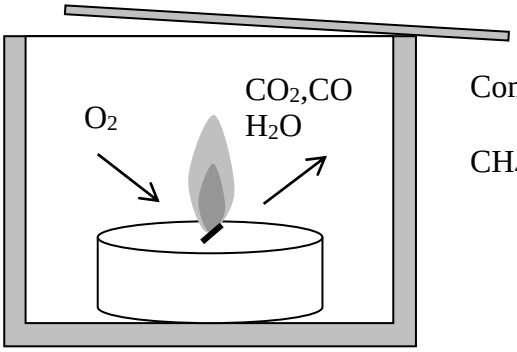
Table 1 – Thermal power needed for heating up 50 liters of water

Time in minutes	Time in seconds	Thermal power in kilowatt
30		
15	900	7,1 kW
5		
1	60	

$$Q = m \cdot c \cdot (t_2 - t_1) = W = P \cdot t$$

$$c = 4260\, J \cdot kg^{-1} \cdot K^{-1}$$

Exercise icon– The following experiment will show us how important it is to pay a flue gas supplied to the burner sufficient oxygen for combustion. As a model torch, we use a small candle placed into a glass. Cover gradually platen glass and watch the process of burning. Caution let not burn. Observe the size and color of the flame. What are the changes in covering up the glass? Even after a partial glass cover with a lid or platen glass accumulates in the exhaust gases as combustion products candle flame. The oxygen supply is inadequate. If you cover the candle it with a glass, the combustion flame of the candle completely suffocate.



Combustion equation for methane in natural gas:

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

Fig. 5 - Diagram of the combustion process in a paraffin candle, in the presence of oxygen.

Exercise icon– If you set the meter to the school (Pasco, Vernier or Phywe) oxygen sensor, carbon dioxide and carbon monoxide, measure the concentration of these gases in the room bigger partially closed container, which is placed a candle and outdoors.

Information icon – The exhaust from boilers combusting gas and solid fuels must be connected to a chimney. Physical principle of passive flue again based on the fact that the hot

air has a larger volume than cold air. It is the same principle as a hot air balloon. The chimney draft is created by the buoyancy of the volume of hot air in the chimney. This applies because the chimney effect is better, the greater the volume of hot flue gases in the chimney and the greater the chimney draft. Some buildings have a chimney with a sufficiently large thrust, and therefore they are used so-called "turbo" boiler with closed combustion chamber and the flue outlet active electric fan.

If the chimney is not effective enough to torch a sufficient amount of oxygen for combustion, then, the combustion of gas or solid fuel is formed in addition to carbon dioxide (di-carbon dioxide CO2) also carbon monoxide (carbon mono-oxide, CO). Carbon monoxide is extremely poisonous yet. The accumulated exhaust gas from a gas boiler or solid fuel boiler in the room so they can quickly poison humans. Carbon monoxide can not be seen or felt. It can occur in older gas boilers due to poor oxygen supply to the room and insufficient chimney draft. Therefore, it is necessary for gas appliances checked regularly by a flue gas path and ensure adequate supply of air into the room.

The flame of the burner gas boiler flue gas buildup during the fizzle and gas escape into the room. Just as dangerous combustion products, it is also dangerous gas leak. Therefore, every gas boiler stops the gas supply immediately. To escaping gas smell, is added to it a substance which strongly and odor. A mixture of natural gas and air is not poisonous. At a certain concentration it can easily ignite accumulated large amounts of explosive mixtures of natural gas with oxygen. Control functions of a gas boiler and water tightness of gas in buildings and therefore performs gasworks workers and plumbers.