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INTERDISCIPLINARY APPROACH TO PHYSICS TEACHING ENHANCED BY COMPUTER-AIDED MEASUREMENT

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Abstract
The poster presents different activities aimed at science teaching enhanced by computer-aided measurement. They represent an interdisciplinary approach to science teaching presenting experiments on biological phenomena based on physical principle. Students can learn about physical laws or see how these laws also work at different biological processes. The activities involve a set of simple computer-aided experiments on human respiration. Time-based measurement of different physical quantities provides an opportunity to analyse these processes in detail with active students´ participation.

1. Introduction
Respiration belongs together with blood pressure, pulse and body temperature to the vital signs. Respiration is the act or process of breathing that runs involuntarily. This biological process is a good example of phenomenon that’s primary function is based on physical principle. Students learn about this process at biology lessons but at the same time the human respiration can be used as a good example to explain the concepts of pressure, underpressure, overpressure, surface tension. This way the students can see how physical laws work at the processes that are close and well-know for everybody. Moreover, time-based measurement of different physical quantities provides an opportunity to analyse these processes or their models in detail with active students´ participation.

2. Simple model of respiratory system
The respiratory system consists of nose, nasal passages, windpipe (trachea) that divides into two branches called bronchial tubes, one entering each lung. The bronchi branch finally becoming hair-like tubes called terminal bronchioles. At the end of them there are microscopic bubble-like structures called alveoli. Each lung consists of about 300 million alveoli. The size of the lungs is controlled by a diaphragm that forms the floor of the chest cavity and the intercostal muscles. When inhaling or exhaling, the diaphragm drops down or up, the ribs expands outward or settles down, causing changes in the size of the chest cavity. The air is drawn into or out of the lungs, consequently.
Simple model of lungs based on this mechanical principle can be easily made by students. A used plastic bottle with cut bottom as a rib cage can be closed by a rubber stopper with holes, glass tubes as a trachea and bronchial tubes, rubber baloons as lungs and a latex glove can be used as a diaphragm (fig. 1).This model can be equipped with a pressure sensor connected to computer via a COACH interface system to measure the changes in pressure while breathing (fig.1).

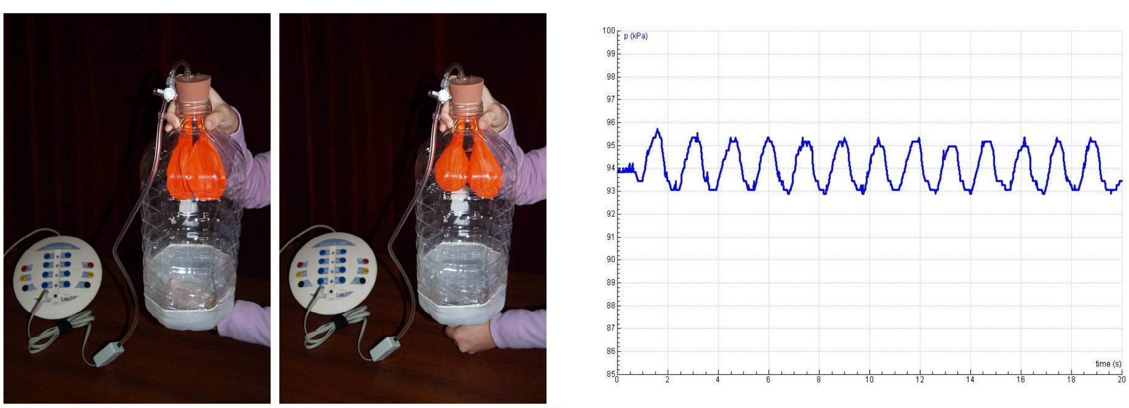

Figure 1: Model of lungs (left) and pressure vs. time diagram (right) measured by COACH system on model.

3. What is the respiration frequency?

Respiration pattern can be measured with the help of COACH interface system and a thermocouple sensor that is used to measure temperature of the air during exhalation and inhalation. According to the temperature vs. time graph one can measure and compare the respiration frequency, respiration pattern in rest and after an exercise, gender differences, etc. In the fig.2 the respiration frequency of the person is about 20 min^{-1}.

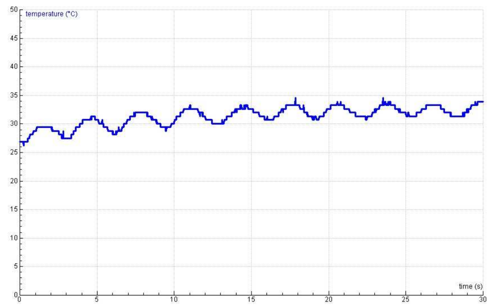

Figure 2: Respiration pattern measured for a person in rest.

4. How deep in the water you can breathe with the snorkel or how much underpressure or overpressure one can generate with his lungs

The activity explains how deep one can dive using snorkel to breathe and why the snorkels sold in shops are up to 30 cm long. Once we dive under water except from the atmospheric pressure there is a hydrostatic pressure of the water acting on our chest. When we take a breath we have to act against this overpressure. How big underpressure or overpressure one can generate while breathing can be studied with the help of a simple water manometer made of rubber tube. Measuring the water level difference while generating overpressure (inhaling into the tube) or underpressure (sucking the air in the tube) it can be seen that the maximum water level difference is about 1m. So we can inhale air with a snorkel in the maximum depth less than 1m (fig.3).

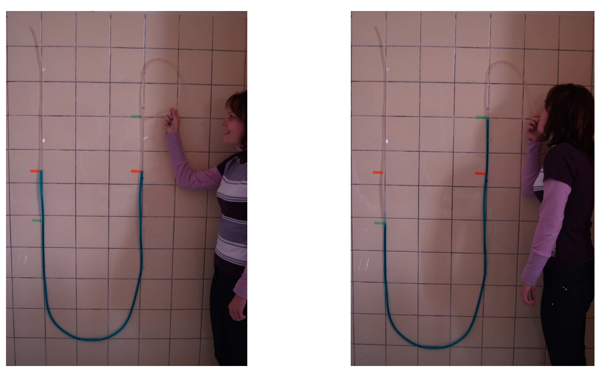

Figure 3: Underpressure generated by a girl measured by water manometer

The same problem can be studied with a computer equipped with a COACH interface system and a pressure sensor. Measuring the pressure while inhaling (sucking the air) through a rubber tube we can measure the maximum underpressure that one is able to generate in his chest. The maximum underpressure created is about 10 kPa (boy) and about 5kPa (girl), i.e. the maximum depth to be able to breathe is 1m and 0,5m respectively (fig.4).

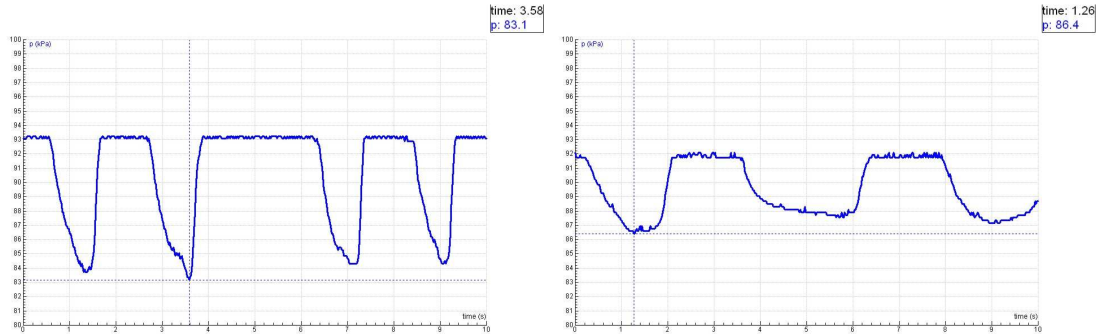

Figure 4: Underpressure generated by a boy (left) and a girl (right) measured by the COACH system

5. How much underpressure one can generate by sucking

In this activity students can study what is the height one can drink a juice through a straw. What underpressure one can generate by sucking the air can be studied with the help of a 4-5m long plastic tube that is let down into a jar with juice, e.g. from a staircase or from a ladder. Another way is to measure underpressure with a computer equipped with a COACH interface system. The results show that the generated underpressure corresponds to about 3-4m. Such a high underpressure cannot be generated by our chest; it is generated by pursing one´s lips. (fig.5)

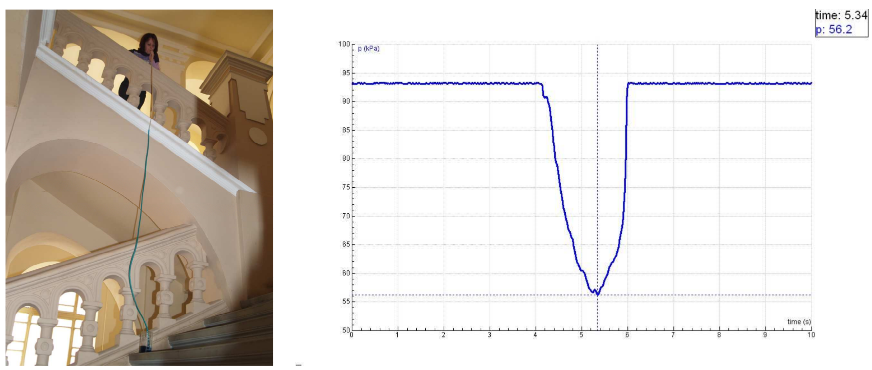

Figure 5: Underpressure 37100 Pa generated by lips (corresponds to 3,71m approx.)

6. Conclusion

All the presented activities show how the interdisciplinary approach enhanced by computer-based laboratory tools can be used in science teaching to attract students' attention to understand physical concepts on processes that are close to them. Other experiments illustrating respiratory system explaining the concept of surface tension can be also designed in order to explain the role and importance of pulmonary surfactants in lungs. All these activities can be carried out in MBL with active students' participation or they can be assigned as students´ project work where students prepare all the materials needed, set up and carry out all the experiments. The results can be presented by the students in front of the class either at the physics or biology lesson.

Acknowledgements

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