APPLICATION OF THE TABLE MANAGER PROGRAM IN THE PHYSICS EDUCATION

Tamás Beke

Abstract: In the 21st century the acquirement and transmission useful knowledge has a key role not only in Hungary but in the whole world as well. In my opinion, the interdisciplinary integration helps teaching efficiently more things than teaching each subject separately. The meaning of integration is approximately that we put together and combine different items and processes. Secondary school students usually get acquainted with the use of table manager programme e.g. Excel. Even with this programme they are able to solve such tasks in which they have to define/estimate the quality of physical amounts, delineate functions so we can hide physics in table manager programmes. I have chosen some physical problems in terms of mechanics: firstly I describe the physical process's basic features, the pertinent laws, formulas (both maths and physics play an important role) then we model this physical process with this table manager program. The use of the Information and Communication Technologies (ICT) at school is one of the basic ideas of modern education; besides providing information, it brings the development of skills in the foreground. In the middle of the teaching process there is such activities which are related to the subject or field in question. So in pursuance of it, the main aim of school education is to provide knowledge that is flexible and can be used later in different fields of life and prepare students to be able to learn and apply this newly acquainted knowledge through their lives.

Key words: table manager software, ICT, physics

1. Introduction

I don't have to emphasize, that there is obviously a need to prepare young people for a future that will require good scientific knowledge and an understanding of technology. Science literacy is important for understanding environmental, medical, economic and other issues that confront modern societies, which rely heavily on technological and scientific advances of increasing complexity. At the Lisbon summit of 2000 Heads of State and Government of the EU recognised that Europe's future prosperity is dependent on creating an environment in which the use of knowledge becomes the cornerstone of socio-economic development. The Lisbon summit placed the spotlight on the need for European countries to turn Europe into the most competitive knowledge-based economy in the world. The summit recognised the need for action: action to foster a knowledge-based society and action to promote education and training [1].

The OECD (Organisation for Economic Cooperation and Development) report (2006) "*Evolution of Student Interest in Science and Technology Studies*" identifies the crucial role of positive contacts with science at an early stage in the subsequent formation of attitudes towards science. However, the study also highlights that, while young children have a natural curiosity of these subjects, traditional formal science education can stifle this interest and therefore can have a negative impact on the development of attitudes towards learning science [7].

The origins of the declining interest among young people for science studies are found largely in the way science is taught in schools. The traditionally used educational form at school is the "*Deductive Approach*", where the teacher presents the concepts, their logical – deductive – implications and gives examples of applications. To be used, the children must be able to handle abstract notions, what makes it difficult to start teaching science before secondary education.

In contrast of the deductive method there is "*Inductive Approach*": the *inquiry-based science education* (IBSE) has proved its efficacy at both primary and secondary levels in increasing children's and students' interest and attainments levels while at the same time stimulating teacher motivation. The two approaches (deductive and inductive) are not mutually exclusive and can and should be combined in any science classroom to accommodate for different kinds of scientific topics, different mindsets and age groups preferences [1].

In the Rocard-report under the *Science and Society* part it calls for the "*creation of an open environment which triggers curiosity for science in children and young people, by reinforcing science education at all levels, including schools, and promoting interest and full participation in science among people from all backgrounds*" [1].

The development of information technology (IT) has challenged learning environments to adopt ICT to support learning and teaching and in guiding children to become its diversified users. Using the computers serves as a trigger for transformations and technology-enriched instructional innovations, which involve profound changes in and affect the very nature of entire learning environments. Even though ICTs are nowadays widely utilized in education around the world as tools for instruction, there are tremendous challenges for developing pedagogically innovative and quality practices for technology-enhanced education. „*It is essential to take the knowledge of human development and learning as a basis for understanding the needs for which diverse technologies of learning should be developed and how they can be better designed to satisfy diverse learners, learning environments, and communities*" [15]. The criterions concerned significant changes in the roles of teachers and students are the following:
- the goals of the curriculum, assessment practices, and/or the educational materials or infrastructure;
- the substantial role or the added value of technology in pedagogical practice;
- the innovation with positive student outcomes;
- emphasizing the potential of the sustainability and transferability of the innovative practice from one classroom to the entire school, to the local region, or even further levels [15].

The OECD report "*Encouraging Student Interest in Science and Technology Studies*" (2008) shows that encouraging interest in science and technology studies requires action to tackle a host of issues inside and outside in our education system ranging from teacher training and curriculum design to improving the image and knowledge of science and technology careers [6]. The science (maths, physics, chemistry, IT) teachers are responsible for the improvement in the image of science too.

On Mathematics classes, students are often given such exercises in which they have to solve some physical problems, moreover I more and more often meet among IT tasks those which subject is physics. The fact that mathematical skills are needed on physics and IT classes is not a surprising fact for anyone. So if we consider Maths, IT and Physics as independent disciplines or school subjects, we can see they get along well with each other and use the other's methods and knowledge. If we use this fact consciously in secondary school education, we actually achieve the integration of them.

In our lives we are hailed by such a great amount of knowledge that we are not able to work off. That is why we have a huge responsibility in forming the students' lives. It is not all the same what kind of knowledge students acquire and how they adopt it.Hopefully more and more teacher will recognize that beside the old and traditional methods, we are in need efforts to renew these. All of us have to use the modern conveniences and teach our students to do the same [8, 9]. Those who teach IT must present students how widely they are able to use computers. Everyone is aware of physical models so they are appropriate to be used to help students to develop IT, programming or even mathematical skills.

2. Table manager program

Many people think that computers are only good for difficult languid and lengthy calculations. For this work computer is the most capable device, but it can be used for more simple tasks. We will easily persuade anyone of this fact if we mention word processing. Nowadays traditional typewriters totally disappeared and are replaced by word processing programmes.

As a communication tool, a table allows a form of generalization of information from an unlimited number of different scientific contexts. A table is both a mode of visualization and a means of arranging data. Modern table manager software applications give users the ability to generate, format, and edit tables and tabular data for a wide variety of uses [2, 3].

Excel has been the most widely used spreadsheet application available for PC since '90s. A spreadsheet displays multiple cells that together make up a grid consisting of rows and columns. The intersection of a row and a column is a cell: each cell contain either text or numeric values or a formula that defines how the contents of that cell is to be calculated from the contents of any other cell or combination of cells, and each time any cell is updated [4]. Spreadsheet softwares are frequently used because of their ability to "*re-calculate*" the entire sheet automatically after a change to a single cell is made, and we can use this trait in practice.

3. Oscillations

We meet oscillations in everyday life: for instance light, sound or AC (alternating current); oscillation is the repetitive variation of some measure about a central value (equilibrium or balance) or between two or more different states. Oscillation is a type of harmonic motion, typically periodic in time and in one or more dimensions; a mechanical oscillation is called sometimes vibration. In the state of equilibrium the vector sum of the forces on the object is equal to zero [10, 12].

3.1. Simple oscillation

A simple mechanical oscillating system is a mass (m) hanged to a linear spring. The spring force (F_{s0}) is proportional to the displacement of mass (Δl); in the balance position the size of gravitation force (F_g) and of the spring force are equal:

$$F_g = F_{s0}, \tag{1}$$

$$m \cdot g = D \cdot \Delta l. \tag{2}$$

If the system is displaced with y from the equilibrium, there act a restoring force on the mass. The force of spring resilience (F_s) tends to return the mass in spring to a position of balance. According to Newton's second law of motion:

$$F_g - F_s = m \cdot a, \tag{3}$$

$$m \cdot g - D \cdot (\Delta l + y) = m \cdot \ddot{y}. \tag{4}$$

Using (2), after simplyfing we get:

$$- D \cdot y = m \cdot \ddot{y}. \tag{5}$$

Considering a single cycle the oscillating mass moves from a certain point in a certain direction then reverses direction and returns to the original point. In this ideal situation the friction play no part, the mass will continue to oscillate without end and the solution of equation (5) is a sinusoidal oscillation:

$$y = A \cdot \sin(\frac{2\pi}{T} \cdot t + \varphi), \tag{6a}$$
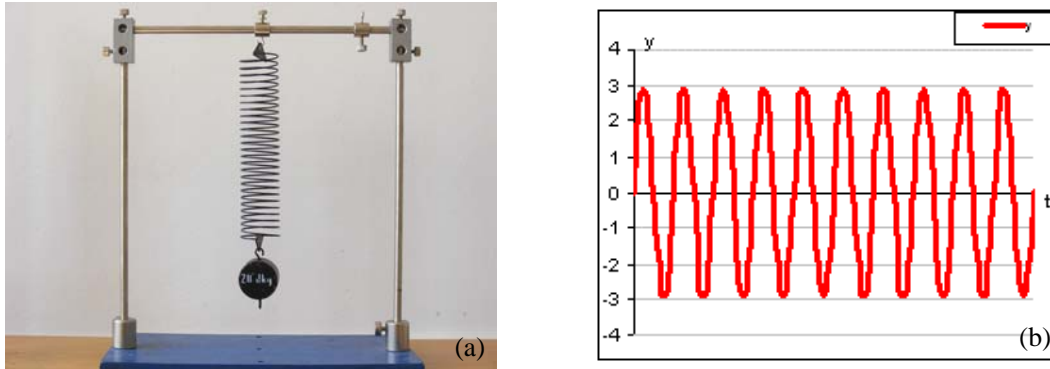
$$v_y = \frac{dy}{dt} = \dot{y} = A \cdot \frac{2\pi}{T} \cos(\frac{2\pi}{T} \cdot t + \varphi), \tag{6b}$$

$$a_y = \frac{dv_y}{dt} = \frac{d^2 y}{dt^2} = \ddot{y} = -A \left(\frac{2\pi}{T} \right)^2 \cdot \sin(\frac{2\pi}{T} \cdot t + \varphi), \tag{6c}$$

and

$$T = 2\pi \cdot \sqrt{\frac{m}{D}}, \tag{7}$$

where the amount of time it takes to complete one cycle is called a period (*T*), *D* is the spring constant, the maximum displacement of particles during a single period of oscillation is the amplitude (*A*), the φ is the phase and the frequency is definied as *f*=1/*T*. On the picture 1 can be seen a simple harmonic oscillation.


Picture 1. *(a) A simple mechanical oscillating system is a mass hanged on the vertical spring; (b) sinusoidal oscillation*

How can we use the Excel to solve the problem? On the picture 2 can be seen the application of the table managing. When you use cell references in Excel formulas, the formulas will automatically update whenever the relevent data in the spreadsheet changes.
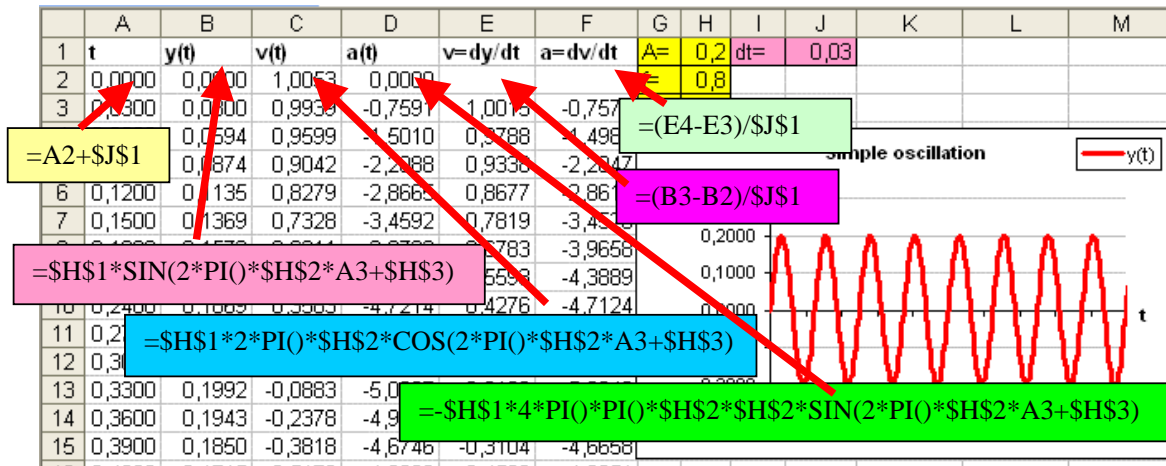
Picture 2. *Using the Excel to solve the physical prolblem. t: time, y(t): deviation in time, v(t): velocity in time, a(t): acceleration in time, v=dy/dt: computed velocity, a=dv/dt: computed acceleration*

A graph (chart in the Excel) is a visual representation of worksheet data. A chart often makes it easier to understand the data in a worksheet because users can easily pick out patterns and trends illustrated in the graph that are otherwise difficult to see. The quickest and easiest way to create a chart in Excel is to use the Chart Wizard [2, 3]. On the picture 3 we can compare the original "*ideal*" velocity and acceleration of harmonic oscillation to the computed ones: if the "*time step*" (d*t* in J1 cell) is relative small (i.e. d*t*→0) then there is a good agreement in the data. A 16-17 years old pupil can't solve a differential equation in maths, but he/she is able to give an approximative solution with the help of table manager.
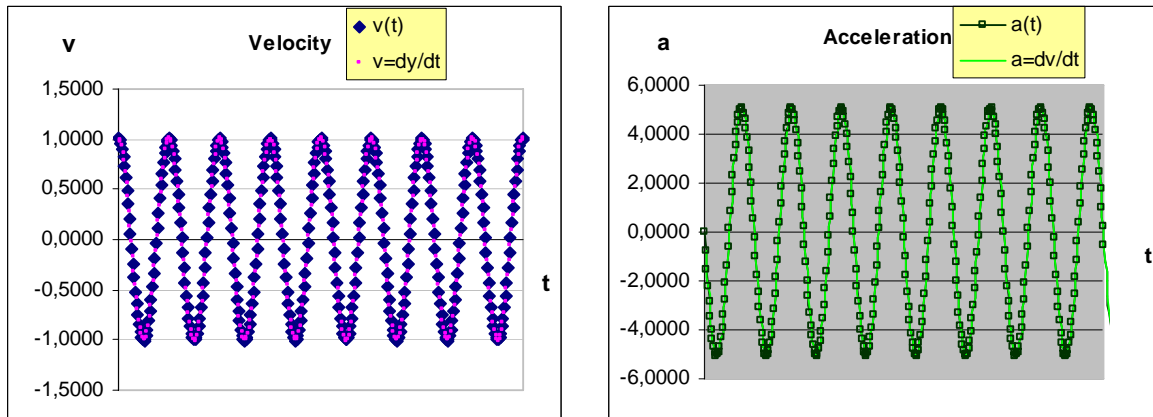
Picture 3. *(a)The ideal and the computed velocity (b) the ideal and the computed acceleration*

3.2. Damped oscillation

Objects in the real-world system do not experience perpetual oscillation: most oscillating particles are subject to damping. The dissipation of energy (conversion of energy into the thermal energy of the environment) is primarily the result of friction. During the time the movement of mass in spring will become slower and slower, because of the damping effect of frictional force (F_f). The friction will gradually reduce the energy that gives it movement, at the end the mass will come to stop [14]. The friction force proportional to the velocity of oscillating mass (v_y). According to Newton's second law of motion:

$$F_g - F_s - F_f = m \cdot a, \tag{8}$$

$$m \cdot g - D \cdot (\Delta l + y) - k \cdot \dot{y} = m \cdot \ddot{y}. \tag{9}$$

After simplyfing we obtain [5]:

$$-D \cdot y - k \cdot \dot{y} = m \cdot \ddot{y}. \tag{10}$$

If the damping effect is small, the amplitude will gradually decrease, as the object continues to oscillate, until eventually oscillation ceases; the result of equation (10) is a „damping oscillation":

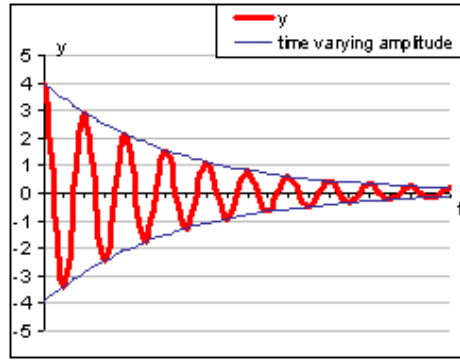$$y = A \cdot e^{-\beta \cdot t} \cdot \sin(2\pi \cdot f \cdot t + \varphi), \tag{11}$$

where β is the damping coefficient [5]:

$$\beta = \frac{k}{2 \cdot m}, \tag{12}$$

and the frequency is:

$$f = \frac{1}{2\pi} \sqrt{\frac{D^2}{m^2} - \beta^2}. \tag{13}$$

We can see that the vibration continually decreases in amplitude, because the oscillating system is sending out energy (picture 4).

Picture 4. *Damping oscillation (weak damping)*

If the damping effect is too strong the object may be "*overdamped*", it completes only a few cycles before ceasing to oscillate. It is sometimes desirable that the vibrating material could return to equilibrium as quickly as possible without further oscillations: e.g. shock-absorber of the automobile (picture 5).
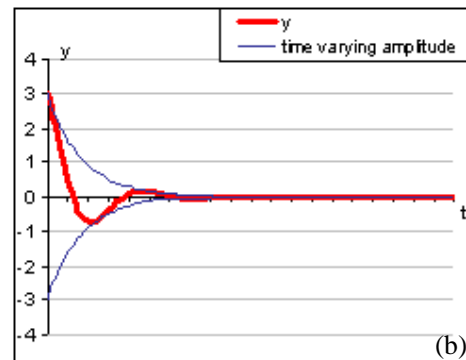
Picture 5. *Overdamped oscillation (a) simple model of shock-absorber; (b) strong damping*

4. Superposition of two harmonic oscillations in the same direction

Considering the interference of two simple harmonic oscillations in the same direction we get a new vibration.

4.1. Two oscillations with the same frequency

The two displacements of vibrations are given by:

$$y_1 = A_1 \cdot \sin(2 \cdot \pi \cdot f \cdot t + \varphi_1), \qquad (14)$$

and

$$y_2 = A_2 \cdot \sin(2 \cdot \pi \cdot f \cdot t + \varphi_2). \qquad (15)$$

The resulting displacement:

$$y = y_1 + y_2 = A \cdot \sin(2 \cdot \pi \cdot f \cdot t + \varphi), \qquad (16)$$

where A is the amplitude of interference:

$$A = \sqrt{A_1^2 + A_2^2 + 2 \cdot A_1 \cdot A_2 \cdot \cos(\varphi_2 - \phi_1)}, \qquad (17)$$

and the φ phase can be get from the equation:

$$tg\varphi = \frac{A_1 \cdot \sin \varphi_1 + A_2 \cdot \sin \varphi_2}{A_1 \cdot \cos \varphi_1 + A_2 \cdot \cos \varphi_2}. \qquad (18)$$

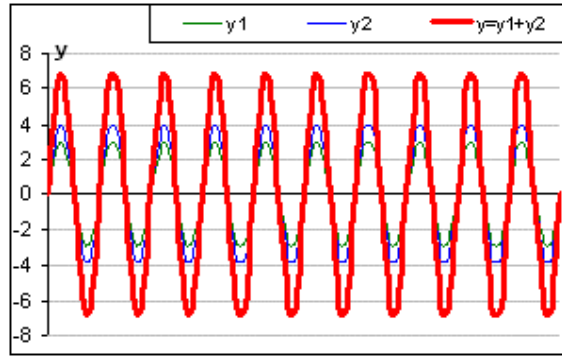The result is a harmonic oscillation with the same frequency as the original vibrations (picture 6).
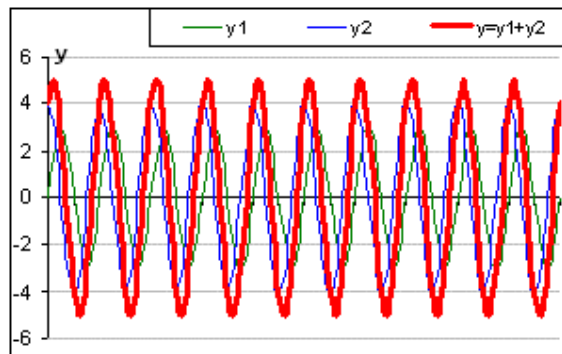
Picture 6. *Superposition of two oscillations with same frequency in the same direction*

Special cases:

Reinforcement: the two motions are in phase, i.e. $\varphi_2 - \varphi_1 = 2k \cdot \pi$ and $k \in \mathbb{Z}$ (picture 7). The amplitude of the interference is:
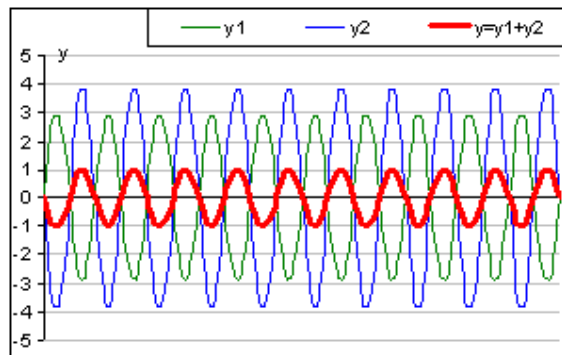
$$A = \sqrt{A_1^2 + A_2^2 + 2 \cdot A_1 \cdot A_2 \cdot \cos(0)} = A_1 + A_2. \qquad (19)$$
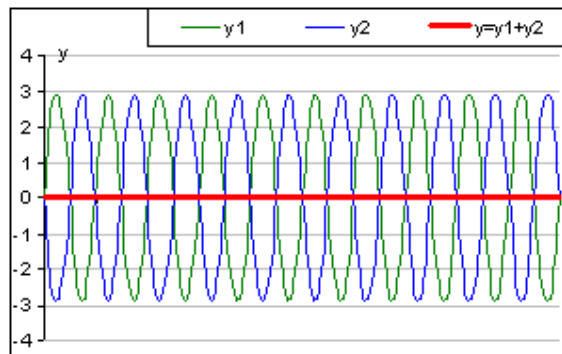
Picture 7. *Reinforcement in interference*

<u>Attenuation</u>: the two motions are in opposite phase, i.e. $\varphi_2 - \varphi_1 = (2k+1)\cdot\pi$ and $k \in Z$ (picture 8). The amplitude of the interference is:

$$A = \sqrt{A_1^2 + A_2^2 + 2 \cdot A_1 \cdot A_2 \cdot \cos(\pi)} = |A_2 - A_1|. \tag{20}$$

Picture 8. *Attenuation in interference*

If the two amplitudes are equal ($A_1 = A_2$), they completely cancel each other (picture 9).

Picture 9. *Cancellation in interference*

4.2. Two oscillations with different frequency

If we have two harmonic oscillations in the same direction but frequencies are different the resultant motion will not be periodical in general:

$$y_1 = A_1 \cdot \sin(2 \cdot \pi \cdot f_1 \cdot t + \varphi_1), \tag{21}$$

$$y_2 = A_2 \cdot \sin(2 \cdot \pi \cdot f_2 \cdot t + \varphi_2), \tag{22}$$

$$y = y_1 + y_2. \tag{23}$$

<u>Special case</u>

If the amplitudes are equal ($A_1=A_2=A$) and the initial phase of the first oscillation is zero ($\varphi_1=0$), then we can write:

$$y_1 = A \cdot \sin(2 \cdot \pi \cdot f_1 \cdot t), \tag{24}$$

$$y_2 = A \cdot \sin(2 \cdot \pi \cdot f_2 \cdot t + \varphi), \tag{25}$$

$$y = y_1 + y_2 = A \cdot [\sin(2 \cdot \pi \cdot f_1 \cdot t) + \sin(2 \cdot \pi \cdot f_2 \cdot t + \varphi)]. \tag{26}$$

We can use that

$$\sin(\alpha - \beta) + \sin(\alpha + \beta) = 2 \cdot \cos \beta \cdot \sin \alpha. \tag{27}$$

Let

$$2 \cdot \pi \cdot f_1 \cdot t = \alpha - \beta, \tag{28}$$

and

$$2 \cdot \pi \cdot f_2 \cdot t + \varphi = \alpha + \beta. \tag{29}$$

Adding (28) and (29) and dividing 2, we obtain:

$$\alpha = \pi \cdot (f_1 + f_2) \cdot t + \frac{\varphi}{2}. \tag{30}$$

Subtracting (28) from (29) and dividing 2, we take:

$$\beta = \pi \cdot (f_2 - f_1) \cdot t + \frac{\varphi}{2}. \tag{31}$$

If we write (28), (29), (30) and (31) in equation (27), then we get:

$$\sin(2 \cdot \pi \cdot f_1 \cdot t) + \sin(2 \cdot \pi \cdot f_2 \cdot t + \varphi) = 2 \cdot \cos[\pi(f_2 - f_1) \cdot t + \frac{\varphi}{2}] \cdot \sin[\pi(f_1 + f_2) \cdot t + \frac{\varphi}{2}]. \tag{32}$$

Applying (32) in (26) we can obtain:

$$y = A \cdot 2 \cdot \cos[\pi(f_2 - f_1) \cdot t + \frac{\varphi}{2}] \cdot \sin[\pi(f_1 + f_2) \cdot t + \frac{\varphi}{2}]. \tag{33}$$

If $f_1 \approx f_2$ then we can experience very slow variation in the „amplitude", so we can write (33) in the following form:

$$y = A^*_{\text{beat}} \cdot \sin[\pi(f_1 + f_2) \cdot t + \frac{\varphi}{2}], \tag{34}$$

where A^*_{beat} is the so called "*beating amplitude*", and it is varying slowly in time with the frequency $|(f_2 - f_1)/2|$:

$$A^*_{\text{beat}} = A \cdot 2 \cdot \cos[2\pi \cdot \frac{f_2 - f_1}{2} \cdot t + \frac{\varphi}{2}]. \tag{35}$$

This situation occur when two similar tuning forks of close but different frequencies are vibrating simultaneously at nearby places. We can hear the fluctuation of the intensity of the sound, this phenomenon is called "beat". The superposition of the two oscillations is shown on the picture 10.
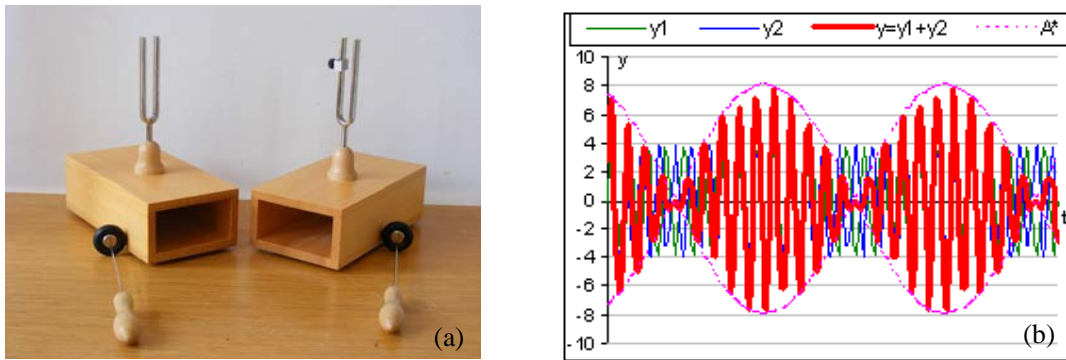
Picture 10. *(a) Two tuning forks of close but different frequencies are vibrating simultaneously at nearby places; (b) beating oscillation*

5. Superposition of two harmonic oscillations in the normal direction

If we have two perpendicular oscillations: one along the x axis and the other along the y axis and the result come from the addition of the two oscillation, then the product is a two dimensional curve, the so called Lissajous picture. The vibrations are represented by sinusoidal waves. Let A and B denote the amplitudes, f_1 and f_2 the frequencies, φ_1 and φ_2 the phases and t the time:

$$x = A \cdot \sin(2 \cdot \pi \cdot f_1 \cdot t), \tag{36}$$

$$y = B \cdot \sin(2 \cdot \pi \cdot f_2 \cdot t + \varphi), \tag{37}$$

which describes complex harmonic motion. This family of curves was investigated by Nathaniel Bowditch (who used a narrow stream of sand pouring from the base of a compound pendulum to produce the curves in 1815), and later in more detail by Jules Antoine Lissajous in 1857 [11].

Before the modern computer graphics Lissajous pictureses were typically generated using an oscilloscope. Two phase-shifted sinusoid inputs are applied to the oscilloscope in X and Y channel-mode and the phase relationship between the input signals is represented a Lissajous curve. We dont have any oscilloscope in our school, but we can use instead of it the Excel to draw the curves.

5.1. Linear oscillation

If the two perpendicular oscillations have the same frequency and the phase is the multiple of π ($f_1=f_2$ and $\varphi=k\cdot\pi$, where $k \in$ Z), then the result is a line. We should eliminate t between the equations (36) and (37): dividing the first equation by A and the second by B, squaring the results, after subtracting we get [1]:

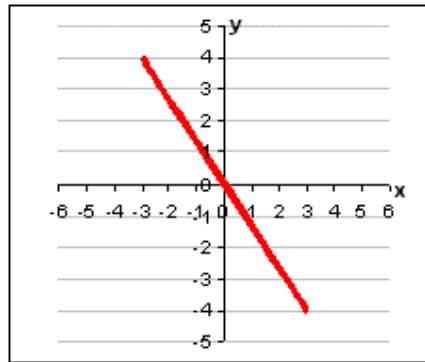$$\frac{x^2}{A^2} + \frac{y^2}{B^2} - \frac{2xy}{AB}\cos\varphi = \sin^2\varphi. \tag{38}$$

If $\varphi=k\cdot2\pi$, then the result is alinear oscillation:

$$y = \frac{B}{A}x, \tag{39}$$

if $\varphi=(2k+1)\cdot\pi$, then the result is a line too:

$$y = -\frac{B}{A}x. \tag{40}$$

On the picture 11 we can see a linear oscillation.

Picture11. *Linear oscillation*

5.2. Elliptical oscillation

If the two normal oscillations have the same frequency ($f_1=f_2$) and the phase is the odd multiple of $\pi/2$, (that is $\varphi=(2k+1)\cdot\pi/2$, where $k \in Z$), then the result of equation (38) is an elliptical oscillation.
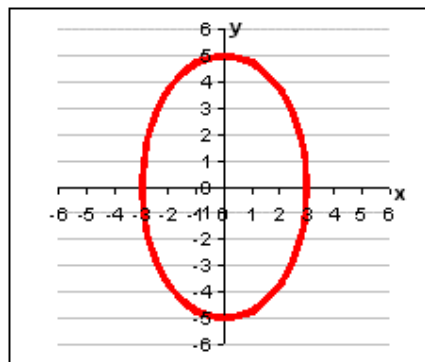
If $\varphi=\pi/2+k\cdot2\pi$, then the result is:

$$\frac{x^2}{A^2} + \frac{y^2}{B^2} = 1, \tag{41}$$

a rightwards polarized ellipse.

If $\varphi=3\pi/2+k\cdot2\pi$, then the result is $\dfrac{x^2}{A^2}+\dfrac{y^2}{B^2}=1$ too, but it is a leftwards polarized ellipse.

(If the two amplitudes are equal, then the result is a circle.) On the picture 12 can be seen an elliptical oscillation.


Picture 12. *Elliptical oscillation*

If we let the phase difference vary continuously, the ellipse will slowly change its orientation and shape, (forming a circle if $A=B$) then go to the line (when $\varphi=k\cdot\pi$) and back to ellipse.

If the frequencies are unequal, the curves are much more complex.

5.3. Lissajous curve

If the frequency ratio f_2/f_1 is a rational number, the curve—no matter how compound—will eventually repeat itself, causing the motion to be periodic. The pattern produced by the intersection of two

sinusoidal curves is a "finite picture", called Lissajous curve. On the picture 13 we can see some Lissajous pictures.
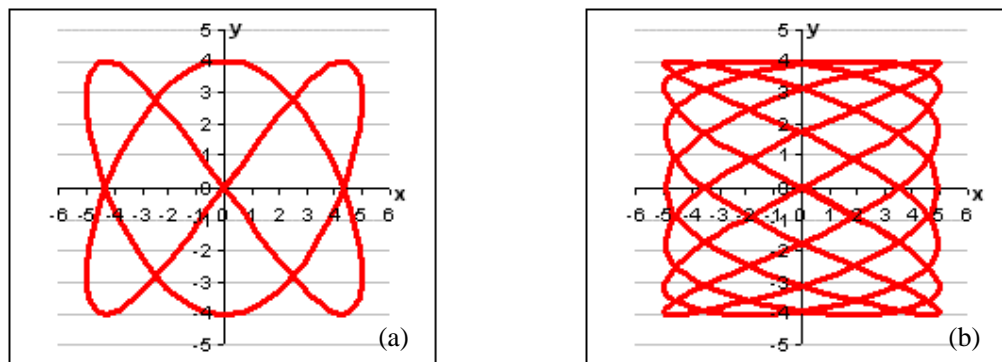
Picture 13. *Lissajous pictures (a) f2/f1=3/2 and φ=0; (b) f2/f1=4/7 and φ=π*

5.4. Infinite curve

If the frequency ratio f_2/f_1 is irrational the point oscillating will never retrace its own path, resulting in a non-periodic motion. However, as time progresses the curve will gradually fill the "border box" (*-A<=x<=A* and *-B<=y<=B*).
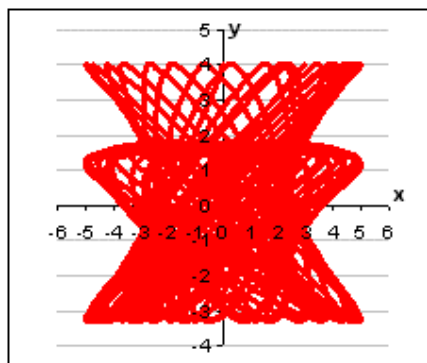
Picture 14. *Part of infinitive Lissajous curve (f2/f1 is irrational)*

6. Conclusion

The science education community mostly agrees that pedagogical practices based on inquiry-based methods are more effective, than the deductive ones. Using IBSE methods has been shown to have a positive impact on students' attainments, with an even stronger impact on the students with lower levels of self-confidence and those from disadvantaged backgrounds [1]. Improvements in science education we can reach through new forms of pedagogy; the introduction of inquiry-based methods in schools should be actively promoted and supported. Trans-disciplinary activities, using of ICT, group work, experience of open-ended problems, solving open-ended questions and problem based learning are the key-words in the school of 21.st century. IBSE is beneficial to promoting girls' and boys' interest and participation in science activities; the inquiry-based practices may be used to create the most favourable conditions and attitudes (interest, self-confidence) to reach the deepest levels of knowledge for the most talented, creative and motivated students too.We can say, that the inductive IBSE methods are also effective as good as in all walks of life in the education.

Among the principles and aims of teaching IT, it is conceived of that IT at school is not only a single subject, but it has to be a device of the effective education. The teaching process is entirely reformed by the use of IT and electronic devices. It creates a new opportunity for the transmission of knowledge, for learning through experiments and for the development of the methods of education in

groups. The concentration of subjects helps the fulfilment of these aims and gives place to communicative lessons, enhances the role of creativity and efficiency in class.

Different oscillations (e.g. light, sound) are physical phenomena that we experience on a day to day basis. During modelling of physical oscillation processes with computers we use the beneficial features of them: they make complex calculations quickly, they illustrate complicated curves immediately and we or students can dilate or vary data in exercises [13]. Computer programmes can be expanded and numerous new tasks can be solved due to them. We can tell that not only the students' knowledge about vibrations was developing, but also their scientific model-thinking and their ability to apply computer and use IT in Physics lesson. Students will hopefully take fancy in using their IT and physical knowledge together and take and advantage of it. I sincerely hope that I was able to present the opportunities for teachers using interdisciplinary methods.

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Author

Tamás Beke, Our Lady Catholic Institute, Nagyasszonyunk Catholic Grammar School, Kalocsa, Hungary
e-mail: bektomi@citromail.hu

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