Cultural History of Physics in a Subjective Way

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Introduction

It is a great adventure to investigate the history of the discoveries in physics and the great physicists' lives.
Designed for engineering students we introduced a new, optional course at our technical college: the Cultural History of Physics.

The role of the Cultural History of Physics

The history of physics can help a lot in studying the main laws of physics: it is easier to understand them knowing the life of the physicist, and the historic and cultural background of the discovery. It helps to raise interest in *getting further knowledge* in physics and in the cultural surroundings of the discoveries. It is easier to remember the laws of physics using associations from the stories. We can confirm that there is only one integrated culture, showing the important parallels between science and art.

Approach

The history of physics is always subjective. The *special* subjectivity in this course means it *complements* a compulsory introductory course in physics.
The main flow of the course is divided into two parts. In the first part we focus our attention on the stories of the physicists' lives, and the cultural surroundings or the parallels with other physicists or artists, emphasising the *cultural history.* We do not describe the laws of physics, because this is done in the compulsory course. The second part deals with the topics, omitted from the compulsory course.
At the end of the course there is a special chapter about the *role of Hungarians in the history of physics*.

Structure of the Cultural History of Physics

- **Emphasis on cultural history:**
    1. Ancient physical and technical results
    2. Interests in the results of mathematics and physics from the Middle Ages
    3. The relationship between art and optics in the 15^{th} - 17^{th} centuries
    4. Geniuses of the 17^{th} century: Galileo, Newton and their contemporaries
    5. Discoveries in the field of electromagnetic phenomena in the 17^{th}-19^{th} centuries
    6. From the nature of heat to the heat engines of the 19^{th} century
    7. The 'classical' models of atomic structure
    8. Leading characters in special relativity and quantum mechanics

- **Emphasis on physical laws (the physical base of modern technical applications):**
    9. History and fundamental phenomena of acoustics using computer programs
    10. Interesting facts from the history of physics of condensed matters - from their discoveries to their applications (thermoelectric phenomena, LCD, superconductivity, lasers)
    11. History of the nucleus from radioactivity to the use of nuclear energy
    12. Historical overview of the fundamental particles and fundamental interactions
    13. Hungarians in the history of physics

Tables of chronological order

At the beginning of each chapter we present a chronological table about the physicists of the investigated period and some of the contemporary artists.

Examples of the type of lectures

a) Pythagoras and Fibonacci in physics and in the other regions of culture

The history of physics can not exist without mentioning mathematicians. There are mathematicians, whose names can be connected not only to physics, but also to other regions of culture. This is the main reason for the following examples: the Greek philosopher and scientist, *Pythagoras*, and the Italian *Fibonacci*.

The basic scientific principle of **Pythagoras** (and of his religious sect, the Pythagoreans) was:

"All things are numbers." They gave simple numerical relationships between tones in common musical intervals: if you create a musical tone by plucking a string, then using simple string ratios (2:1, 3:2, 4:3), they produce musical intervals that sound harmonious. They had a concept of a floating, spherical Earth. They gave a proof of the Pythagorean Theorem, and hence came to the concept of irrational numbers, which was very difficult even for them to accept.

Fibonacci (Leonardo di Pisa) was probably the most famous and productive mathematician of the middle Ages. But the reason why his name is so well known in the different regions of culture is the so called Fibonacci numbers: 1, 1, 2, 3, 5, 8, 13, … In the following centuries more and more interesting characteristics of this sequence emerged, giving rise to further applications of Fibonacci numbers. The limit of ratios of the subsequent terms of the Fibonacci sequence is the "golden number", or *golden section*, the ratio of two distances which causes a harmonic image in our mind. We meet the *golden section* in many paintings and also in architecture. By regarding the number of spirals of seeds in a sunflower, we find a good correlation with the Fibonacci numbers. Examples of the existence of the Fibonacci numbers can be found even in physics:

"Having a so-called 'ladder network' circuit with seven 1 Ω resistors, and assuming that the current in the last resistor is 1 A, we find that the voltages on the succeeding resistors follow the Fibonacci numbers." [1]

b) Laser history

As a preface to the physics of lasers there is a short historical preview. The following shows its short summary as an example of historical aspect of the second half of the semester.

LASER HISTORY

Stimulated emission	**1917**	**Einstein**
Holography	**1947**	**Denis Gábor**
		Nobel-prize: 1971
Maser	**1954**	**Townes – Baszov and Pohorov**
		Nobel-prize: 1964
Laser	**1958**	**Schawlow and Townes**
Laser spectroscopy		**Schawlow and Bloembergen**
		Nobel-prize: 1981
Rubin laser	**1960**	**Maiman**
Semiconductor	**1963**	**Alferov and Kroemer**
		Nobel-prize: 2000
Laser cooling	**1980**	**Chu, Cohen-Tannoudji and Phillips**
		Nobel-prize: 1997

Multimedia in teaching the cultural history of physics

- ***Computer programs in the teaching of acoustical phenomena***.

We use a very impressive computer program to show the basis of acoustics and some technical applications. (At the same time it means the application of my experiences from the previous GIREP conferences, where the authors of the used book and CD [2] had excellent presentations.)

- ***Films about the meeting of Bohr and Heisenberg in 1941.***

There are two films considered: an English documentary and a feature film based on the Michael Frayn drama, Copenhagen. Both are very challenging in their highlighting of this special historical episode. One of them is projected on the course. One of my students wrote the following note filling the questionnaire (see later): "The viewing of the film should be *'compulsory'* on this course also in the future."

Students' opinion about the course

Details of the results:

How did you find the ratio of history to physics on the course?

- It was appropriate: 65,5%
- I would prefer more *history*: 24%
- I would prefer more *physics*: 10,5%

Presentation of the parallel between art (painting) and physics (optics) was

- interesting: 65,5%
- interesting, and I would have preferred more similar lectures: 27,5%
- not too interesting : 3,5%
- unnecessary: 0%

Presentation connected to acoustics was

- interesting and helped to understand the basic concepts: 55%
- interesting: 38%
- not too interesting: 3,5%
- unnecessary: 0%

The film about the meeting of Bohr and Heisenberg was

- interesting and helped to know and understand the two physicists: 65,5%
- interesting: 21%
- boring: 7%
- unnecessary: 0%

To mention the artists in chronology was

- interesting in knowing the age and the circumstances of a discovery: 79%
- not enough, I would have preferred more: 7%
- unnecessary: 14%

Finally let me show two of the questions from the exam of the spring semester of 2005:

- *Who was the English physicist in the 19th century, whose activity extended beyond physics; he was also a painter, doctor, musician, and linguist?*
  A. Newton, B. Huygens, C. Young, D. Fresnel.

[1] Why do we celebrate especially 2005 as the year of physics?

References

[1] Simonyi K., A fizika kultúrtörténete, Budapest, 1998
[2] Mathelitsch L. and Verovnik I., Akustische Phänomene, Köln, 2004