Physics and Art at the University

Dr Dorottya Sebestyén

Óbuda University, Sebestyen.dora@kvk.uni-obuda.hu

Abstract: *In the introductory physics and history of physics courses, one of the aims must provide our students not only with an overview of physics but also the whole culture. On the way to achieve this aim, and at the same time making physics more interesting and understandable, we have to find the meeting points of the so called "two cultures", especially of art and physics. The selected examples intend to provide illustrations to teaching mechanics and optics. This presentation is the part of the result of a research of years, dealing with this topic from different point of views. The subject of this paper is not the process of research but simply an intention to offer suggestions for improvement of physics teaching by using a special theme as a basis of associations or as models.*

Keywords*: physics; painting; literature; music*

1 Introduction

"If we really want to say anything at all about nature, we must somehow pass from mathematical to everyday language." (Niels Bohr)

Elements of physical laws can be found - directly or indirectly - in numerous paintings and poems, and we can also find connection between physics and music or sounds of music. We can use them when we teach important physical concepts, because of their motivating power or for modelling physical phenomena.

Nevertheless the courses of the history of physics offer more possibility to use these types of illustration, as it happens at our university, in the Cultural History of Physics course.

2 Physics and Art in the Culture

Although Galileo, Pascal and Tycho Brahe lived at the same time with Shakespeare, Velázquez, and Monteverdi, usually we do not deal with them in parallel ways. (Figure 1) We can understand the works of these people - who were

far from one another in space and in the most cases in activity - by placing them side by side into the course of history of physics which is embedded in the general history of culture.

Figure 1

3 Illustrations for Some Chapters of Mechanics

3.1 Measurement of Time

Measurement of time is very important in mechanics. Its history can be followed by the history of art. Let us see just one example. The Clock in Florence's Cathedral is the only clock of the world that shows the so called Italian time. (Figure 2) Paolo Uccello made the colored dial of the clock in the 15th century. On the face of the clock the Roman numeral XXIIII is at the bottom, and it designates the hour of sunset (that was the time that the gates in the high walls surrounding the city would close). He also designed the single golden shooting star-shaped hand that circled his fresco, denoting the time. It moves like the shadow of a sundial, counter to the movement of the sun, it means that the clock runs counter clockwise. In the 17th century, Galileo designed a pendulum for the clock, improving the clock works.

Figure 2

3.2 Dynamics

We can discover the process of the movement itself in Giacomo Balla's painting: Young Girl Running on a Balcony. (Figure 3) The painter attempted to realize movement by showing the girl's running legs.

Figure 3

The law of action and reaction (Newton's 3rd law) can be illustrated by Rodin's sculpture, Eternal spring. (Figure 4) It can suggest to the physics teacher that you are not able to kiss without be kissed, in other words, there is no action without reaction.

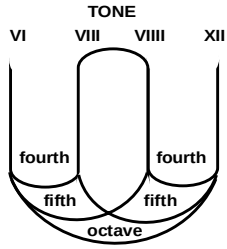
Figure 4

3.3 Acoustics

Giacomo Balla: *The Hand of the Violinist* can be a possible link between the motion and the acoustics. (Fiure 5)

Figure 5

It was in ancient times that the Pythagoreans found the mathematical proportions behind the harmony of music. This fact can be discovered looking at Raphael's *School of Athens*. Here, in front of Pythagoras, the Greek words and the Roman numbers refer to the connection between the ratios of the lengths of the plucked strings and the intervals producing harmonious sounds - if these ratios are the ratios of small numbers. (Figure 6)



Ratio of numbers	Ratio of small numbers	English interval	Greek interval
VI : XII	1 : 2	octave	diapason
VI : VIIII	2 : 3	fifth	diapente
VI : VIII	3 : 4	fourth	diatessaron

Figure 6

We encounter references to the Pythagorean musical theory in other works of art as well. For example Leonardo da Vinci's contemporary was Gaffurius, who emphasized in his book of musical theory the importance of the ratios of Pythagoras. So Leonardo, who knew him, divided the background of *The Last Supper* according to the musical ratios: the width of the second tapestry is the half of the first one, then the next one is the third of it, and the following one is the fourth part of the first one.

Let me quote a poster from the exhibition in the Globe theatre: "Throughout his work Shakespeare makes reference to music and musical instruments, often using them in his plays for their symbolism. A recent count suggests more than 4000 references. Since the days of Pythagoras – 6^{th} century BC – music had been associated with the movement of the stars and planets. All was well when there was harmony in the spheres, but discord meant trouble ahead. Shakespeare used this idea again and again."

Nowadays the analysis of the sound can be applied to model different physical laws. Let me show only one example here. One can think of *entropy* as a quantitative measure of the degree of the *lack of information*. Nowadays perhaps this is the best approach to make this quantity more familiar to our students: we can show it by presentation of the basis of the digital sound recordings. In this process we have to compress enormous quantity of data without a significant degree of information loss. (Figure 7)

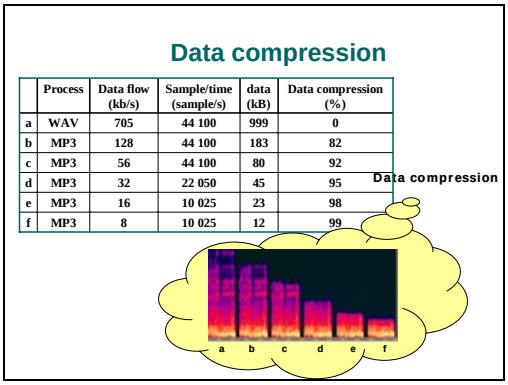


Figure 7

3.4 Illustrations for Optics

The convex mirror in Quinten Metsys' *The Moneylender and his Wife* can be used to illustrate the law of reflection. (Figure 8) In the mirror we can see a window and probably the portrait of the painter himself, according to the projection of the convex mirror.

Figure 8

We also can meet the definition of the mirror in Dante's work, *Divine Comedy* :

And thence the foreign radiance is reflected,
Even as a colour cometh back from glass,
The which behind itself concealeth lead.

Dante: Divine Comedy, Paradiso II. (translated by H. W. Longfellow)

The picture created by the mirrors can be also discovered in this work:
Three mirrors shalt thou take, and two remove
Alike from thee, the other more remote
Between the former two shall meet thine eyes.
Turned towards these, cause that behind thy back
Be placed a light, illuming the three mirrors

And coming back to thee by all reflected.
Though in its quantity be not so ample
The image most remote, there shalt thou see
How it perforce is equally resplendent.

Dante: Divine Comedy, Paradiso II. (translated by H. W. Longfellow)

Conclusions

In this paper I intended to show a special way of the possibility how paintings, poems and the sounds of music are able to illustrate physical phenomena or laws, helping the better understanding.

In order to summarize the ideas above, let me mention the following. The different areas of culture work like a puzzle. To understand the world around us, we have to know science, its different branches (one of them is physics), and art, its different branches (like painting, literature, music). Each of them can be seen as a piece of the puzzle.

Acknowledgement

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