Physics for “the others” (motivation)

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Introductory remark

I keep lectures on physics at the Faculty of Mathematics and Physics of the Charles University in Prague. My students are partly future (theoretical) physicists, partly „the others“ – those who never will develop physics actively (or, who don’t know it yet). They are students of mathematics in the 1st course, of informatics in the 3rd course and future teachers in the 3rd course.

Motivation

I think the motivation is very important even at the university level. The motivation is like the authority: internal and/or external. Internal motivation is caused by the attitude, the opinions and the internal needs of the student; it is felt immediately, without any mediation. It leads to the need of understanding the topic and then including it in its own “arsenal” enabling to think in the new terms and ideas. The external motivation is caused by the external structures and binds: the social need to own a title, a given plan of studies etc. It leads to the need of the successful absolutory, which is not just the same as the previous need. It may include even memorizing the verbal text of formulation (even with its evidence) instead of understanding, in the worst case even to cheating by exams.

Students of physics

Generally, the students of physics are never in doubt, even when sometimes some students feel, say, the thermodynamics being not noble enough comparing, say, to the quantum field theory.

„The others“ generally

„The others“ are in different situation. Of course, they feel that the centre of mass of their interest lies somewhere else and they thing more economically how much energy should they spend for physics. Further, some specific negative tendencies occur:

- Generally, some negative attitude to physics is caused by the improper attitude of corresponding teacher at the secondary or even primary school. Mostly, the experiments will help.
- Some of students consider the physics as a collection of formulae and laws, most of them even not being valid in the practise – and what for a law that is not valid exactly? Then, some preliminary discussion about the complexity of the nature and the proverb “divide et impera” improves the situation.
- Other students compare the “exact” mathematics with the “superficial” physics, where the equations have been simplified, and even all “unpleasant” terms are neglected. Like just before – and first of all, the comparing of the gotten results with the experiments justifies the superficiality. With some humour, the slogan “The only difference between the mathematicians and the theoretical physicists is that we know what is negligible” will help, showing the meaning of from the observation of the nature and the fact that

instead of the given models studied by the mathematics, the physics studies the very nature round us – or, even most exactly, the artificially chosen parts of the nature, where just the art of splitting the nature is one of arts of the physics.

- Very often they miss the fact that the physics studies and explains the real world round us (and quite successfully, need to say). In the secondary school, most of experiments has been done "by chalk and board", and labs – if any – were rather confusing than the "adventure of the recognition". The confrontation with the reality helps a lot; some open problems will make all the topic more attractive, and the true confession that "many things we still don't known and/or cannot explain– they are waiting for you" is for some students the best stimulation, for other a "fair play with open cards", socially better acceptable than pretending some omnipotence.

Those aspects must be considered if the lecture should be successful. By the way, that's why it is not recommended generally to join two lectures even with the same name for students of different specialisation.

„The others" particularly

My lectures of physics for the students of ***informatics*** (who sometimes suffer by bad practice in calculus) are rather – cum grano salis – of a popularisation style. Demonstrations and describing many applications of physics are vital. Particularly, the lecture about acoustics is attractive every year and is often visited even by former students who have heard it already.

For the students of ***mathematics*** there is a nice, specific problem in calculus.
1) It is necessary for explaining of basic mechanics;
2) From the begin, some students are preliminary informed about but far not all of them;
3) during first year all of them pass the lecture of mathematical analysis, where the well-known ε-δ calculus is discussed exactly and in the full depth.

To be understandable from the very begin and not to be under suspicion of dilettantism later on, I put down a "Calculus for the physics" together with my colleague – mathematician. Students are allowed to use it (even by exams) to stress the fact that it is meant as a tool, not as a matter of the lecture.

To stress the "common interests" of mathematics and physics, I use any opportunity to mention the names they know from the mathematical analysis (Riemann, Cauchy, Euler, Lagrange…) and their impact in solving problems e.g. from the mechanics of continuum. The group theory serves as a nice example of the pure theoretical discipline that found very broad application in the solid-state physics, whereas the Dirac's δ-function shows vice versa the inspiration from the side of physics (distribution theory, weak convergence etc.). The fact that some of mathematical "pearls" has been found to order of practical physical problems helps to the students to find the proportions and the place of the mathematics in the whole of human knowledge.

Education of teachers – the key problem

Lectures for the future teachers are the most demanding. Mostly, they have a strong internal motivation: they feel the need to understand it deeply to be able to explain it to their pupils in the future. Nevertheless, they have many other lectures as well. Some parts of math (Fourier transformation, δ-function) they don't know; it is necessary to explain it when used on physics together with the application. Of course is it the best motivation, but as well it is quite time consuming. A careful choice and limiting of the topic is necessary, keeping in consideration their future profession.

Today's student, well motivated, will later at the secondary (or even primary) school teach pupils still unmotivated, just building their scale of values. Today's society does not

appreciate sciences, regardless the fact that our quite high standard has been done and kept just due to the top technology and science. In fact, “alternative” sciences or “para-sciences” (read “anti-sciences”) are much more popular and attractive to people. At the first view, one can see some important factors:

- Only very small part of the society’s resources is necessary to and is used to keep the basic needs of people to survive. It leads to the tendency “to postpone all basic problems to the specialists” and not to take any care for it at all. It is true that e.g. just the basic research in such an impractical thing like the surface resistance of such an exotic material as the germanium led to the finding of transistor and all the technology based upon, from digital clock, PC, cell telephone to the greatest computer-controlled systems. Nevertheless, this fact in this form does not stimulate people to take the care for science.
- Every day’s technology round us is too complex and complicated to be understood, not saying to be actively influenced. The medieval hay-wagon was probably not home made, but surely home-repaired – may be with some details from the next smith. This is not the case of our cell telephone, TV or PC. At any apparatus you read “No serviceable parts inside”. As a result, it is a weak motivation that the science helps us in the every day’s life.
- The general trends are to be found from the very professionals –the marketing and advertisement specialists. You rather reed “Buy our machine – for the use you needn’t to understand it at all” than “Buy our machine – you will easy understand how it works.” As a result, it is even a weak motivation that the science helps us to understand the behaviour of things from the every day’s life.
- May be the strongest motivation is that the physics is amusing, beautiful, interesting. We may be disgusted by the “Barnum’s manners”. But if we really want to sell our product – physics … ?

It is rather task for psychology and sociology to describe and to handle those phenomena. Nevertheless, both general pedagogy and special didactics should reflect it.