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## Teaching philosophy

One of the most challenging questions I have ever posed myself is: **What is a "teacher"? And, consequently, what does "teaching" mean?**

At first, the fascinating complexity of the exercise left me disoriented. Searching for an answer felt like wandering through a labyrinth. Every answer turned out to be unsatisfactory. For example, a teacher is far more than just a person standing in front of a group of individuals and dispensing standardised, ready-to-use knowledge. If the goal were to create exercise-solving machines, handbooks would be enough and no teacher would be needed. Is a teacher, then, perhaps a person who is very passionate about a subject and tries hard to make others see the beauty of it? Not necessarily. Let's say that a person, whom we call Mr. Jones, brings a difficult concept across to his audience, but without feeling particularly involved in the topic and without stimulating the inquisitiveness of his interlocutors. Although this is not an ideal situation, I would find it somewhat contradictory, or at least unfair, to say that Mr. Jones is not a teacher. After all, his audience got the message that he intended to convey!

Since a direct confrontation with the question was not helping me, I asked myself the following: **Why do I find it so difficult to define what a teacher is?** The conclusion I came to is that the complexity must lie in the breadth of the teacher's role. The aspects of an individual's personality which can be stimulated by a teacher are numerous and various, and so are the tools at the teacher's disposal. Thus, the definition of "teacher" would have to be very broad. In particular, such a definition would have to transcend the various subjects in favour of a synthesis of the simultaneous processes of teaching and learning. And this was the key to escaping from the labyrinth.

I am deeply convinced that there is no teaching without learning, and vice versa. Thus, the teacher is someone who induces a learning process in other individuals or himself (in this second case, the person is self-teaching). But what does it mean "to learn"? To me, learning is synonymous with change. After learning, a person is different than he or she was before. The required change is activated by interactions which the learning person has with others or himself. Among all possible interactions, the most effective are those beginning with a question. In this case, in fact, an active thinking process is stimulated in the person searching for the answer. People need to train their innate ability to think actively, conditio sine qua non for becoming free individuals and original contributors to any endeavours they may engage with. Thus, optimally, **the teacher is a means to convey questions.**

The conclusion I came to is reminiscent of the classic Socratic approach. Nevertheless, I see an important difference between the two. From my perspective, irony and maieutics, the two pillars of Socrates' method, should not be unidirectional. There should not be one Socrates and someone else, but rather two Socrates challenging each other. In the end, why should both interlocutors not profit from the same situation to train their own active thinking? In such a playful Socratic arena, the traditional roles of teacher and student disappear. **In a classroom, everyone is teacher and student at the same time.** When my students ask me questions, they automatically become the "traditional" teacher, and I the "traditional" student, as they have induced active thinking in me.

Although I was happy with my conclusion, it was immediately clear that I had escaped from one labyrinth only to enter another! In fact, finding the path to follow is often only part of the solution. The other is how to travel along it. So once I had discovered what the "ideal teacher" means to me, the next question was: **How do I realise this ideal?** Fortunately, physics is a wonderful playground for just this exercise. Critical thinking has been the essence of physics from its very beginning. Thus, the spectrum of strategies I can develop is incredibly broad. In particular, I focus on three correlated key aspects of students' approach to the subject: their attitude, the skills they should develop and their role in the classroom.

> **ATTITUDE:** I invite students to be sceptical and to doubt everything I say. Students should challenge me with questions until they are convinced. "Prove me wrong!" is the game I propose. To enforce this message, I sometimes deliberately give incorrect information and await their reaction. Alternatively, when discussing a physical model, I may lead students toward a specific approach and then ask a question based on an opposing point of view. Obviously, the questions I pose are various and not restricted to these "educational traps". Some are specific, such as: "Does the order of magnitude you have found make sense?", "Is this approximation legitimate?" or "Is your data sufficient to solve the problem?" Others are more general and are kaleidoscopic variations of the key question "What are we doing and why?" I also try to stimulate students' innate curiosity. For example, I have had successful experience in explaining how a coffee machine or a refrigerator works, or in presenting counterintuitive quantum or relativistic effects. Offering an insight into recent discoveries such

as gravitational waves, in which I was actively involved, has also proven to be very effective. Additionally, I tell numerous historical anecdotes. In this way I try to make students aware of how powerful the brain can be as an investigative tool and also “humanise” the subject. My favourite anecdotes are about Eratosthenes and his method of measuring the size of the Earth from shadows in wells, as well as the fight between Galileo and the ipse dixit-based cultural approach of his time. Ipse dixit: the epitome of the conscious rejection of freedom I ask my students to avoid!

**SKILLS:** Along with the aforementioned key capacity to think critically, there are a number of additional skills I want students to develop. Some examples are abstract thinking and the ability to perform back-of-the-envelope calculations. I help students train the former by, e.g., asking them to identify the main assumptions behind the physical models studied and their range of validity, and to find connections and similarities between different phenomena and topics. To improve the latter, one of my favourite tools is the use of Fermi problems, magnificent playgrounds for training the fundamental capacity of making estimates and recognising the most significant variables. The ability to work in a team is also essential. For this purpose, I often assign challenging exercises that students solve in groups. Another important skill students should develop is the ability to present well-structured and mathematically rigorous solutions. To support them in this task, I give extensive written feedback as part of the correction of their tests and assignments. I also ask students, when solving exercises, to write brief texts (two or three sentences) explaining their approach and the principles it is based on. Apart from offering me a further useful insight into their understanding of the subject, this written production helps students put ideas together in the framework of a logical concatenation of thoughts.

**ROLE:** I encourage students to take a very active role in their learning. They are welcome to come to the board to explain how they would proceed with the formal description of a particular physical phenomenon, or to share their solutions to the assigned exercises. Moreover, the frequent activity at the board helps students develop the art of conveying messages and exchanging opinions. Students are also invited to propose exercises they will then solve. The most important contribution I ask of them, though, is their feedback: about me as a teacher and about what we should change or do to improve the course, to help them develop their own approach to learning, to critical thinking and, if they so desire, to becoming co-authors of the thrilling, constantly edited book describing Nature which we call physics.

Dear reader, as an endnote please let me emphasise that what you have just read is, like every physical model, temporary. Teaching is an art and, to be an artist, it is necessary to be aware that any future endeavour might allow us to resonate and improve, if only we are open to it. And I am, basically, a happy Sisyphus!