

Do Physicists Understand Physics (Voice from Chorus)

- Physics is a quantitative science.
- Galileo declared that “Book of nature is written in mathematical characters”.
- A. Baz’ once said to me “Formulae are more clever than us”.
- M. Markov noted that “Mathematics is the Latin of physics”.
- R. Feynman emphasized that “Mathematics is not just another language. Mathematics is a language plus reasoning; it is like a language plus logic.”
- A colleague once said to me “ They (theoretical physicists) first are writing equations and then are trying to find some physics behind the equations.”
- J. Rigden and R. Stuewer noted that “Equations routinely dominate the papers and books written by physicists with the result that words serve only as transitions between equations. For example
Substituting Eq.(7.9) into Eq.(7.8) gives [equation]. Introducing a new variable [equation], we then find [equation]. This leads to [equation], where L is defined as [equation].”
- D. Hilbert said of Einstein “Every boy in the street of Göttingen understands more about four-dimensional geometry than Einstein. Yet, in spite of that, Einstein did the work and not the mathematicians.”
- In 1933 Einstein said “It is my conviction that pure mathematical construction enables us to discover the concepts and the laws connecting them which give us the key to the understanding of the phenomena of Nature.”

- J. Rigden and R. Stuewer emphasized that “Mathematical symbols are required to express the quantitative; words are needed to delineate the qualitative. The symbols and logic of mathematics come from without; words come from within. The quantitative is governed by the external logic of mathematics and an individual must strictly adhere to this logic; by contrast, the qualitative is controlled by an individual’s internal dictionary.”

- Mathematical tools are powerful but to understand physics behind the equations a qualitative understanding, whether in words or images, is necessary.

- Qualitative problems (see, for example [1,2]) challenge students to think about the physics instead of juggling equations and help them to see a certain beauty and harmony in physics.

[1] A.L. Zubarev, M.M. Musakhanov, V.A. Pazdersky, *Problems in Quantum Mechanics* (Tashkent University Press,1978).

[2] E. Mazur, *Peer Instruction: A User’s Manual* (Prentice Hall, INC., 1997).