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The practical teaching of undergraduate quantum mechanics

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It is more than a hundred years since some of the most basic notions of quantum mechanics were founded, but the subject still remains largely a mystery and conceptually a difficulty for many first time students. Some treatments of the introductory material tend to lean more toward the formalism and the theoretical underpinnings of the subject. Yet, today, quantum mechanics is a very practical tool that has been applied successfully to a wide range of research areas in physics, such as in condensed matter physics, solid state physics, nuclear physics, etc., and increasingly now in areas outside physics such as in chemistry, biology, etc. And so, the question must be asked whether our teaching of the subject has kept up with developments at the high end of research. The author has endeavored to bring more excitement to the subject by focusing on practical applications, including computational examples. Drawing close parallels with the classical world, which undergraduate physics students are usually more accustomed to, has proven to be invaluable in making the teaching of quantum mechanics more tangible, practical, and understandable to first time students. For example, the classical particle in a 1-D box corresponds to the particle simply bouncing back and forth at constant speed. The classical probability density p(x)=1/a where a=width of the box. It is useful in this example to discuss the meaning of this probability density from a classical standpoint which is related to the time-averaged motion of the particle. The quantum mechanical probability for this system, namely p(x)=|phi(x)|ˆ2, has some useful similarities and differences. The interpretation of the quantum mechanical probability density is related to an ensemble average and not a time average. Furthermore, it is useful to see how the classical result for p(x) emerges from the quantum mechanical result for high quantum number. The same approach is useful for the harmonic oscillator, and other simple systems.

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