Wonderful papers

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Here are some of my favorite articles — I find them especially valuable from a teaching perspective.

- *Evaluating creative solutions* (Radnai, 1984)
  Inspired by a problem in electromagnetism, this short article questions how a teacher should assess students who produce creative yet incorrect solutions. Creativity and unconventional thinking are essential for opening new avenues of research in Physics and Mathematics. As both a student and a teacher, I believe that mistakes play a crucial role in personal growth and in building increasingly solid foundations for learning. Indeed, scientific progress itself is based on countless failed attempts and wrong turns. This principle extends beyond education—it applies to life as a whole.

- *Planetary motion and the duality of force laws* (Hall & Josic, 2000)

  In the study of motion in central fields, the gravitational force $\vec{F}_g \propto -\vec{r}/r^3$ and the Hooke force $\vec{F}_g \propto -\vec{r}$ share some remarkable similarities: both allow for elliptical orbits (though with different characteristics) and, more importantly, they are the only two force fields for which all bounded orbits are closed—according to Bertrand's theorem. These similarities are not mere coincidences: there exists a theorem (due to Bohlin) showing that these two fields are actually different versions of the same law, related through a conformal transformation in the complex plane. And it does not end there—there are infinitely many power-law central fields that can be paired according to a specific relation between their exponents! Isn't that fascinating?

- *Tutorial on electromagnetic nonreciprocity and its origins* (Asadchy et al., 2020)

  During the late development of the electromagnetic theory, several misconceptions arose from the association between time-reversal symmetry and Lorentz reciprocity. Even today, some still believe that one necessarily implies the other. In reality, this is not the case. This long article provides a theoretical overview of the concept of reciprocity in electrodynamics and also examines the differences with time-reversal symmetry. It is a must-read for anyone working in condensed matter physics.

- *Ray tracing in concentric gradient-index media: optical Binet equation* (Liu, 2022)

  I have always been fascinated by the fact that different physical theories can often be described by the same underlying mathematics—and I'm not talking about the trivial case of the harmonic oscillator that appears everywhere. Given my love for celestial mechanics, one of the most beautiful analogies, in my view, is that the trajectory of a body moving in a radial field can be mapped onto the trajectory of a light ray propagating through a medium with a spherically symmetric refractive index. The mathematics is exactly the same: even for light rays, one can define a Lagrangian and a Hamiltonian.

- *Classic Bernoulli's principle derivation and its working hypotheses* (Marciotto, 2016)

  Textbooks and online resources are full of misconceptions in fluid dynamics. Unfortunately, many of them are related to Bernoulli's equation and the assumptions underlying its use. Moreover, the standard derivation of Bernoulli's theorem using the

stream-tube method is incorrect in almost every textbook. This article highlights these common mistakes and presents a more accurate version of the derivation based on the stream-tube approach.

- *General formalism for calculating the thermal efficiency of thermodynamic cycles defined in a p–V diagram* (Könye & Cserti, 2022)

  This is a very funny—and fascinating—article to read, as it provides a general method for calculating the efficiency of a thermodynamic cycle of any shape. Except for the simplest cases, the calculation usually requires numerical integration. Among the examples, the authors even include a heart-shaped cycle and a five-pointed star!

- *The electrodynamics of substances with simultaneously negative values of ϵ and μ* (Veselago, 1968)

  Since my Ph.D. focused on metamaterials and macroscopic electrodynamics in media, this article inevitably ranks among my favorites. In it, Veselago, by hypothesizing the existence of materials with both $\epsilon < 0$ and $\mu < 0$, introduced for the first time the concepts of *negative refractive index* and *negative refraction*. Thirty-two years later, Pendry showed how this principle could be used to realize *perfect lenses*, paving the way for modern research on metamaterials.