

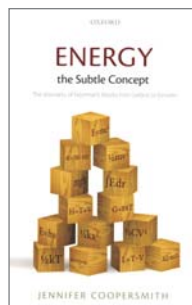
Atomic Force Microscopy is a great introduction to AFMs for beginners and, although light on theory, also serves as a good starting point for more serious users.

Energy, the Subtle Concept

Jennifer Coopersmith
Oxford U. Press, New York, 2010.
\$55.00 (400 pp.).
ISBN 978-0-19-954650-3

Nuclear physicist Jennifer Coopersmith's *Energy, the Subtle Concept: The Discovery of Feynman's Blocks from Leibniz to Einstein* is intended for people who, like me, wonder what energy really means. Coopersmith begins with an anecdote from Richard Feynman about a mother who observes that her son always has the same number of building blocks. Sometimes the blocks are hidden from view—for example, a block may be at the bottom of a murky bath in which the boy mischievously tossed his toy. In that instance, the mother accounts for hidden blocks by measuring the water displaced from the bathtub. Feynman compares her observations to the first law of thermodynamics—the principle of conservation of energy—but notes that in the case of energy, there are no blocks. Energy can be measured and quantified, and it is conserved, yet it does not have the same type of material reality as a building

In clear and engaging prose, Coopersmith shows how the modern understanding of energy was formulated, moving from the first documented discussions of simple machines and perpetual motion in ancient Greece, to the work of Gottfried Leibniz and other



17th-century thinkers, to Einstein's theory of relativity and beyond. She highlights the development of conservation laws and mathematical formalisms, as well as the theoretical unification of what we now understand to be different forms of energy. Although Cooper-smith spends the majority of the book discussing the ideas, she also includes a fair of biographical detail about the s involved and provides some d political context.



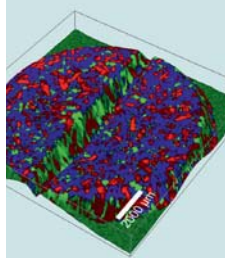
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Does Coopersmith succeed in providing a deep and satisfactory explanation of energy? The book offers a rich feel for the concept, but as I turned the final page I was not convinced that the central question—What is energy?—had been answered. Coopersmith is asking a philosophical question, but she falls somewhat short of a philosophical answer. The closest she comes is her suggestion that energy is a dual concept: at once something that can be measured and “also nothing more than the mathematical formulae” (p. 359). Yet she does not lay out the philosophical implications of that duality: What does it mean that energy is nothing more than formulae but also something that can be measured and conserved? In a way, her answer simply restates the question. And her final sentence—“Energy is: the ceaseless jiggling motion, the endless straining at the leash, even in apparently empty space, the rest mass and the radiation, the curvature of space-time, the foreground activity, the background hum, the *sine qua non*” (p. 360)—is poetic and descriptive but does not carry much philosophical weight.

Could the answer be that energy is nothing more or less than its history? That the meaning of the concept is inseparable from the people and events from which it emerged? At times it seems that is where Coopersmith is headed, especially when she dwells on historical contingencies. However, she explicitly rejects that possibility, maintaining that history can help us understand energy, but the concept transcends the story of its emergence. She opens chapter 2 with the assertion, “Energy was always energy even before it was understood as such” (p. 5).

Further, in her conclusion she writes, “We have seen how [physics] has been discovered in so many places, at so many times, and by such varied people, but the resulting concepts and laws transcend these varied origins” (p. 359). Her commitment to a truth in physics that transcends history thus prevents her historical narrative from answering the central philosophical question. What, then, do we gain by describing the circumstances from which the concept arose? Does history merely make it easier to understand the concept of energy, without providing any novel content to the explanation? It would have been nice to see Coopersmith grapple with those questions more directly.

Because *Energy, the Subtle Concept* is a fascinating read, both physicists and

nonphysicists who want to learn more about the history of energy will enjoy it. It won't completely satisfy philosophically minded students, but the narrative will undoubtedly improve their intuition for the concept.

Lisa Crystal
Harvard University
Cambridge, Massachusetts

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