Teaching Physics by Modeling

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The teaching of the basis of physics varies widely between engineering and physics departments. Whereas students of physics focus on the principles of physics, i.e., on the basic phenomena that govern our physical universe, students of engineering sciences emphasize the interactions between components of physical systems. Thus, whereas the education of physicists is *phenomenological* in nature, that of engineering students is primarily *systemic*. Engineering students learn to think in terms of systems and their interactions. Both viewpoints have their pros and cons. Both are useful, but both deprive their learners of important facets. Whereas physicists often are poorly trained in understanding complex system behavior, engineers often treat the underlying principles like black boxes. As they don't fully comprehend the underlying physical principles, they sometimes overlook inherent limitations of the formulae that they apply to their system designs.

In this presentation, we attempt to bring together the best of both worlds: Understanding is modeling, and modeling is understanding. We shall demonstrate how physics can be taught by modeling, and how this approach helps to deepen the understanding of the underlying physical principles while also supporting systemic thinking.

Numerous examples shall demonstrate how black-box thinking may lead to misconceptions, and how sound physical modeling based on bond graphs can help unveil and correct these misconceptions.