Visualizing Mathematical Foundations of Design Optimization using MATLAB

Yong S. Suh, Mechanical Engineering, California State University-Sacramento

In my experience in teaching the mechanical engineering students in our university, I have learned that many students can engage in learning much better with “hands-on” and application-based approaches that associate real examples backed instead of focusing on the theoretical backgrounds. It is even better if the examples are backed by relevant physical tangible objects or visible simulations through virtual models. This is a little bit different the way how I learned where we focused more on developing theoretical foundations, setting up ideal (simplified so it can be hand-solved) models and developing and solving the mathematical equations calculated mostly by hand on paper. In retrospect, I think it was primarily due to the lack of easily accessible computational tools such as MATLAB, not because of a particular pedagogical reason that practicing theories are fundamentally better in learning.

I teach mostly courses related to engineering product designs including computer-aided design and manufacturing, so my course contents usually do not require solving sophisticated mathematical equations (or they are performed under the hood of the computational software). A few years back, I taught a systems dynamic course due to an emergent situation in my department just before the semester starts. Since I had not enough time to prepare, I taught the students the way I had learned; establishing mathematical equations from free-body diagrams and solving the set of differential equations all by hand on paper. Students struggled even in setting up basic free-body diagrams not to mention solving the differential equations on paper. It was a miserable failure. That experience though helps me developing a completely different approach.

I plan to develop courses on mechanism designs and design optimization that involves algebraic as well as differential equations. Based on the previous experience, I would like to focus more on high-level concepts when it comes to solving mathematical equations by using tools such as MATLAB. Also, instead of numbers, I plan to make the mathematical equations more intuitive than mystery by using various visualization tools. Mathematical solutions of mechanism design (e.g., four-bar linkage designs) can be visualized via virtual digital models such as computer-aided design tools. To do so, an easy way of connecting MATLAB with a CAD tool must be developed. Students can make tangible parts of their designs using a D printing technology. On the optimization, MATLAB’s graphics tools can be used to visualize the objective functions and constraints.