Monan Ma

monan@bu.edu

Teaching philosophy

One of my most rewarding moments was seeing a packed lecture room with students and judges from non-engineering backgrounds understand my explanation of nanomechanical resonance through a gymnastics analogy. This was my presentation during the final round of the 3-Minute Thesis® competition. During my talk, I followed the facial expressions in the audience, and it was clear when the moment of understanding occurred. I think the primary target in presenting to a broad audience and teaching introductory-level courses is similar, and it is to build intuition. I found that using apt analogies can be a powerful technique to achieve this. You can find my adapted presentation and full analogy in the Appendix.

In more advanced courses, however, I focus on clarity and flow, which allows for concepts to build upon one another. I start with the first principles and connect the subject to real-world problems. For example, when explaining the Fourier transform, I would first demonstrate the quality enhancement of a visual image and a piece of music by filtering out specific frequency components. These two examples can build an intuitive understanding of frequency in different contexts. As the story progresses and gradually becomes complex, I ensure there is always a smooth, logical connection between ideas. During a lecture, if I am referring to, for instance, a variable mentioned earlier but not used for a while, I would state the name and what it represents rather than the symbol itself. If something needs to be skipped to not disrupt the flow, such as a lengthy derivation of an equation, I clearly state this and direct students to relevant resources and my office hours if they wish to explore the topic further.

With the abundance of high-quality learning resources, I strive to design learning experiences that surpass what is available on OpenCourseWare or YouTube. For instance, I generally encourage deviations from a traditional lecture format where students mainly listen. Here, I would pose thought-provoking questions and facilitate controlled discussions. I would ask my students about their aspirations and their current projects. I would then connect class concepts to students' interests, thereby enhancing their engagement in lecture discussions.

Teaching experiences and new class proposal

Before my Ph.D., I have taught courses in thermodynamics, engineering dynamics, statics, and an AutoCAD design class as a full-time Visiting Assistant Professor at the State University of New York, Farmingdale (also known as the Farmingdale State College). My teaching reviews are available on my website, and the link is included in the email signature. During my Ph.D., I taught fluid mechanics and statics as a Teaching Assistant, and have given guest lectures in graduate-level courses on finite-element modeling. As a result, I am comfortable teaching a wide range of courses in Mechanical Engineering and Physics.

At the same time, I am excited to develop a more specialized course that incorporates my area of expertise. For example, I would be thrilled to develop and teach a course on numerical simulation using the commercial software COMSOL. To complement more traditional modeling classes that cover the fundamentals of finite-element analysis and use MATLAB, my course would be project-based, focusing on a few problems in Mechanical Engineering, such as fluid-structure interactions, Joule heating in microelectronics, and wave propagation in acoustic metamaterials. I would discuss the underlying physics, starting with static or eigenmode analysis, and then extend it into dynamic response, model validation, and data visualization. My learning outcome is to prepare students for a critical mindset in evaluating simulation assumptions and equip them with the necessary skills to create robust, applicable models in their area of interest.

As a potential faculty member, thoughtful teaching can shape the next generation of cross-disciplinary problem solvers. Refining one's teaching skills is crucial for scientific communication and making research breakthroughs more accessible and extensible for other researchers and posterity.

Appendix: Explaining the working principle of a nanomechanical resonator

Adapted from my presentation at the 3MT® competition

Consider an Olympic gymnast performing a routine on a suspended beam. During the last movement, the gymnast dismounts by pushing off the beam. If one takes a closer look at the suspended beam, it will be vibrating at its natural frequency of several Hz. Now, if we allow this beam to be miniaturized by a factor of roughly a million, one will get a nanometer-scale, doubly clamped beam with a natural frequency in the MHz range. As a nanobeam is incredibly light, even the mass of an adsorbed molecule can considerably increase the total vibrating mass, which results in a measurable change in the beams frequency. By monitoring the frequency change of a beam, one can detect the presence of hydrogen in the air or the mass of a single virus. These nanometer-scale devices, known as nanoelectromechanical systems (NEMS), have applications in biosensing, environmental monitoring, and precision metrology.