BLOSSOMS INTERACTIVE VIDEO LESSON

PSEUDOSCRIPT

TEACHER GUIDE SEGMENT

Hello Teachers. I would like to thank you for introducing this Blossom's Lesson on Elasticity to your students.

Through this lesson, in addition to sharing knowledge, I would like to introduce students to the joy of learning and using the subject of Solid Mechanics early on in their education. I chose Elasticity because it forms the stepping stone to the general subject of Solid Mechanics and it is reasonably easy to introduce at the high-school level. Also, I hope this hands-on, multi-media approach to teaching will complement your own method of inspiring the students to pursue science and engineering education.

The primary focus of this lesson is to introduce the students to Elasticity which is one of the fundamental concepts in the understanding of physics of deformation in solids. As you would know, its applications are extensive - from man-made engineered structures to naturally occurring solid structures such as trees and rock formations and even the human body. The topic is commonly taught in high school physics curriculum around the world using the Linear Elastic framework of the Hooke's law. With this lesson, we will approach the subject from a slightly general perspective – that of Nonlinear Elasticity. The advantage of this approach is that, in addition to giving the students a broader view of Elasticity, with this general paradigm we as teachers can take a hands-on approach to explaining the subject using simple readily available soft objects such as rubber-bands.

Complementary to our primary focus, this lesson can also give the students a glimpse in generating meaningful data for physical systems, performing analysis and finally using the knowledge gained in a practical application. This will enable students to appreciate that the science and mathematics concepts they are learning in school are important from a practical perspective and will hopefully interest students in pursuing an education and a career in engineering and sciences.

In terms of pre-requisites, some definitions and concepts that will be essential for a good appreciation of this lesson will be that of a pure Solid and its distinction from a pure Liquid, Displacement, Velocity, Acceleration, Force, Work and Energy. Additional concepts that might be helpful are simple functions of single variables, numerical integration such as finding the area under the function curve and Kinematic equations of projectile motion. I am of the opinion, that the main essence of Elasticity can be captured by the simple force vs. deformation relationship. However, as you would know for a more rigorous description one needs to bring in the concepts of mechanical Stress and Strain. I avoid introducing them in this lesson because a satisfactory discussion involving Stress & Strain would require a much more sophisticated mathematical machinery. In case you have already introduced the students to these concepts, feel free to incorporate them in the relevant discussions.

Now in terms of the activities that we have planned out, the first activity is to get the students quickly into the groove of our suggested learning-by-doing approach. The main objective of this activity is to enable the students to be able to distinguish different solid objects based on their capacity to deform under load. Here I have suggested some materials with varying degrees of stiffness as well as extent of maximum elastic deformation. Please feel free to substitute them with analogous materials.

The Activity 2 is the first of the two more detail-oriented activities. The goal here is to have the students perform an experiment to generate Force vs. Deformation curve and then analyze the nature of elasticity. Note that here we perform a force-controlled experiment where we increase the load in multiples of the known weight. If you have a Force measuring device at your disposal, you may also conduct this activity as a displacement controlled experiment by changing the length of the sample (rubber-band) in small steps of known length and reading off the force-measuring device. Feel free to substitute the coins with some other known weights that can cause the rubber-band to deform. Also, I prefer to use rubber-bands which are slightly wide so that I can staple them at the ends. The larger width will also be useful in launching the projectile in Activity 3. If time is limited, you may choose to analyze the data from one of the teams. You may note from the video of my execution of Activity 2, the pointer stick was not helpful as it was tilting during the experiment. So, I analyzed the numbers that corresponded to the actual level of the rubber band end from which the plastic cup was suspended. The measurements and analysis is illustrated in the slides (**TeachersGuide_DataAnalysisFiguresForActivities2and3.pdf**) attached with this teacher's guide.

Activity 3 is, in my opinion, the most challenging. I would suggest using light projectile, such as a match-stick or a rubber eraser, for safely conducting this activity. The problem with using a light projectile will be measuring its mass. My suggestion will be to weigh the projectile in a Physics/Chemistry Lab by electronic scales or beam-balance. Since the projectiles will be moving fast, it may be difficult to pin-point the location of its first hitting the ground. It might be a good idea to draw a grid of uniformly spaced parallel lines that are oriented perpendicular to direction of launch on the floor, say at every 4-inch interval. This grid can be drawn in the approximate neighborhood of the projectile's horizontal range for the prescribed stretch of the rubber-band. This will help the student to observe the location of first launch within a tolerance equal to this line spacing. Again, if time is limited, you may choose to analyze the data of one of the teams. The relevant equations and launch scheme are illustrated in the slides (**TeachersGuide_DataAnalysisFiguresForActivities2and3.pdf**) attached with this teacher's guide. Note that in my experiment I found that only 7% of the elastic potential energy stored in the stretched rubber band was converted to the kinetic energy of the projectile at launch. This implies a significant portion of potential energy was released in other forms.

The setups for Activities 2 and 3 are only suggested setups. It is absolutely ok, to adjust the design to accommodate your local class-environment as long as Force vs. Deformation curves and the Kinetic Energy (of projectile at launch) to Potential Energy (of stretched rubber band) ratios can be calculated from Activities 2 and 3. In addition to providing the relevant formulae, we have included an MS Excel sheet (**TeachersGuide_DataAnalysisForActivities2and3.xlsx**) that might be helpful in the fast analysis of Activities 2 and 3. In terms of venue, I will suggest conducting Activities 2 and 3 within a class-room environment. All the rest of the activities can be done in any setting – be it outdoors or in-class.

Finally, Activities 4 and 5 are designed to nudge students to reflect on the activities hitherto and motivate them to come up with their own ideas on potential sources of error in their inference as well as some real-world applications of elasticity. You may also use Activity 5 to gauge the pulse of the class and can work with colleagues and students to identify related topics for future discussion.

Overall, I hope both you and your students will enjoy this lesson. If you have any questions, concerns or feedback, please feel free to email us. I look forward to hearing your experience in conducting this lesson. All the best!

Thank You.

Sourish Chakravarty
Postdoctoral Associate
The Picower Institute for Learning and Memory
Massachusetts Institutes of Technology (MIT)
Email: sourish.chakravarty@gmail.com