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BEAM Lesson Plan (Unity High)

Teaching Plan: Materials, Energy, and Elasticity.

Focus: how different materials react to forces on them, how they deform and use their elasticity to absorb energy.

Intro/Discussion: (10 mins) Introduce students to the theme of different materials, their elastic natures, and how they react to forces. (Verbal, conceptual learning) Demos of rubber bands, how they stretch up to a certain point but break after that point. Also, spaghetti (brittle) versus bendy straws (ductile).

Passing out materials and explaining challenge: (5 mins) The challenge: build a contraption to surround an egg (or other material). This contraption will be dropped from increasing heights to test how well the contraption can distribute the force and leave the egg unbroken. A competition will be held between 3-4 groups to see which group can make the most protective contraption when starting with a restricted set of materials. (Hands-on, active learning)

Challenge, building contraptions: (20-25 mins.) Building contraptions will give students hands-on experience translating what they learned into a group project.

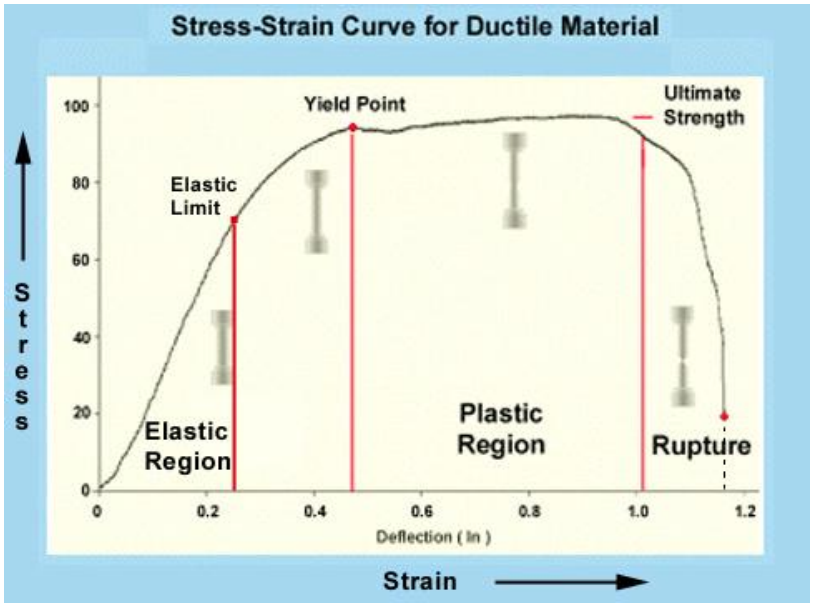
Testing contraptions: (10 mins)

Wrap-up and final discussion: (5 mins.) Discuss what went right and wrong, explaining everything in terms of physical principles. (Learning through reflection, error analysis)

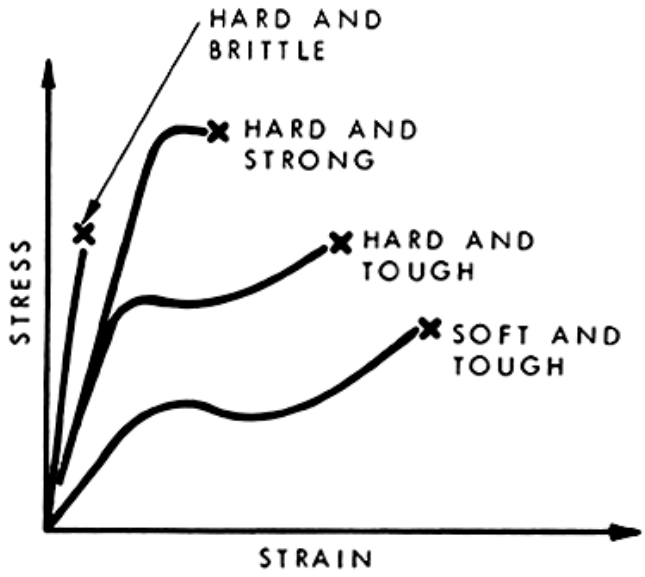
Mentors Scientific Background: Different materials vary greatly in their ductility/brittleness. The molecular structure of the material determines its elasticity, fracture limit, stress limits, etc. Think of a rubber band being pulled to the point where it can recover its old shape, and then to the point where it is permanently deformed – this is called plastic deformation. When increasing stress beyond that point, materials even reach an ultimate stress where fracture occurs.

For an object impacting a surface, if it accelerates to rest over a greater distance/time, it will have a smaller force acting on it and thus be less likely to break. The objective is to reduce the speed of impact, as well as reduce the acceleration to rest, to protect an object from breaking (as in the egg drop). Another aspect is using a protective material which absorbs energy throughout it instead of transferring it all to the object.

Stress/Strain Diagram for Ductile Material:



Comparison with Brittle:



Introduction for Mentees:

Different materials have different strengths, and some break more easily while some don't break easily. Look at a bendy-straw versus a spaghetti noodle – one is brittle, the other is soft and 'ductile'. One breaks easily when you put a force on it, the other one bends and doesn't break.

Look at a rubber band – you can stretch it out, but if you pull it too far, you will deform it and maybe even break it. Some materials, like a string, are not stretchable, but they can be pulled with a higher force. Question: What other materials can you think of that are brittle or malleable? Where are these used?

Also, think about how things react to an impact. Question: Why does it hurt when you fall on the concrete, but not onto a trampoline? When you fall hard, say on the concrete, it hurts a lot more because there is a bigger force on you. When you fall on a trampoline, you aren't hurt because the energy is distributed on the trampoline – the trampoline is more elastic, so it is a softer fall. Basically, if you slow down over a bigger time/distance, you feel a smaller force. If you slow down really quickly, like when you hit the concrete, it hurts a lot more.

Modules/Demos, or Project: Egg Drop:

The class will be divided into 3-4 groups. The groups will compete to make a contraption that will protect an egg/other from being broken when the contraptions are dropped from increasing heights. The group whose egg survives longest will win. Groups will have ~20 mins and a restricted set of materials (see materials) to use to build this contraption. Each group will only be able to use a specific set of materials; BEAM mentors can vary this set based on how challenging they want the assignment to be. It is recommended that all groups are allowed to use all kinds of the materials given, but only a restricted amount (one box, one plastic bag, a certain number of pellets, etc).

This project will emphasize the physical properties of the materials they can use, to demonstrate elasticity and how to distribute force around an object. We'll start dropping contraptions from 5 ft, and increase in increments of 5 ft. Possible prize for the winning group.

Closing Activity and Discussion:

The final discussion will be focused on what went right and wrong in the egg drop, and why. We'll ask each group why they did what they did, and ask what they could have done better. Ask how they would change their design if they were to do it again. Also ask how different materials, hard and soft, are important for engineers to understand and use (real-world applications: cars contracting, etc).

Worksheet : (See last page)

Materials

-Eggs (or other breakable, cheap item), tape, glue, scissors, paper towels, rubber bands, Styrofoam pellets, plastic bags for parachutes, small cardboard boxes/shoeboxes, bendy straws, spaghetti, string

References/Citations:

http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/building-digest-157.html

http://invsee.asu.edu/srinivas/stress-strain/phase.html

(stress/strain diagrams)

EggDrop Worksheet

Questions Prior to Challege:

What materials do you plan on using in your contraption and why?

How will each material type contribute to the overall contraption when impact occurs?

Post-Challenge Questions:

What aspects of your contraption went wrong? Similarly, What went well?

Did your expectation of the types of roles for each material hold up? If not, Why?

Consider what could have been done better:

What materials could have been excluded and probably have given the same result?

Conversely, if asked to do this Challenge again, what would you change? What would you add?