STEM Connections

myQuake miniSystem

Below are ideas of how the myQuake miniSystem connects to STEM concepts and principles. For more ideas and detailed STEM lessons, consult the *myQuake Teacher's Guide*.

ACTIVITY OVERVIEW

Students design and build balsa towers to be resistant to earthquakes. Towers are constructed from balsa wood and precut floor plates that simulate the floors within a tower structure and can be used to add loading to one or more floors of the towers via large washers.

SCIENCE

Ask Questions That Arise from Careful Observation of Phenomena

Have teams of students construct balsa towers of two, three, four, and five or more stories – keeping the height and diagonal bracing of each story congruent between towers.

As a group, students observe the action of the each tower on the myQuake shake table as the frequency is changed slowly from a stopped position to the maximum frequency. From these visual observations, students develop questions that may be answerable from further experimentation or from an analysis of data.

After the visual observations are complete and the questions have been asked, original student teams will use the myQuake with linear accelerometers attached to collect data about their tower at various frequencies. From the empirical data, students should determine (where possible) the resonant frequency of their tower – that is, where the tower undergoes the most violent (therefore destructive) shaking.

Student teams can share and explain their data, and as a group, further questions about resonant frequency and tower height can be determined and explored.

ENGINEERING

Design a Tower Damping System – Iterative Design

Iterative design is a process that engineers follow to modify or improve a product. The process is typically in the form of a design loop – a step-by-step procedure:

- Formulate ideas.
- Determine specifications.
- Research.
- Brainstorm.
- Formulate a solution.
- Prototype the solution.
- Test/analyze.
- Redesign or improve the solution.

Each loop through the process is an iteration.

Students begin with a simple design of a four-floor balsa tower, with standard X diagonal bracing on each side section of each floor of the tower. They test the tower using the Pitsco myQuake and National Instruments' myDAQ to provide data to analyze the structure's response to the shaking.

Students use iterative design to design and construct a damping system to add to their tower – with the objective of reducing the amount of destructive shaking that occurs during an equivalent shaking process. Data before and after the damping system addition is analyzed. Students can continue the process and test further iterations.

TECHNOLOGY

Data Acquisition

Have students brainstorm ideas for minimizing earthquake damage in a four-story tower. These ideas are mental models, providing a framework for development of conceptual (real-world) models that can provide both qualitative and quantitative data for students to analyze.

Students should sketch three or four of what they consider to be their best ideas and then choose one to construct.

The student towers are tested on the myQuake shake table that uses data acquisition through National Instruments' myDAQ module. The acceleration sensors that come with the myQuake can be placed on various floors of the tower – usually one sensor is placed at the bottom of the tower to provide baseline frequency and acceleration data.

Students should observe and record both visual observations and empirical data from using the myQuake. Students can vary the shake frequency and observe the frequency at which the building reaches its resonant frequency – its most destructive shaking point.

Students can rotate the tower 90 degrees to determine if their tower strength is directional. Students can also load the floors of the towers with washers, documenting observations and data with various loading strategies.

MATH

Represent and Model with Vector Quantities

Vector quantities can sometimes be a difficult concept for students to visualize – or connect with a real-world application. However, in nearly every common structure, force vectors are hard at work.

In the context of earthquake-resistant structures, students can physically model a tower design (specifically focusing on the diagonal bracing within the tower) and obtain empirical data by using the Pitsco myQuake shake table in conjunction with the myDAQ data acquisition module from National Instruments.

Students can work in teams to build towers that have diagonal bracing. Each team can build with bracing at a different angle than other teams, or they can build a series of towers with bracing at different angles.

The brace provides a visual of the force vector at work in the diagonal brace – and can be broken into its x, y component vectors to determine the relative amount of force being transferred through the brace in the x and y directions.

By comparing forces measured by the myDAQ sensors on towers with differing brace angles, students can see the difference in transmission of those forces through the braces and determine the physical effect from the change in bracing angle.

PITSCO EDUCATION

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