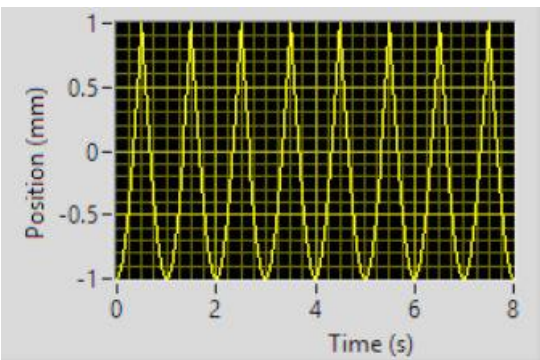
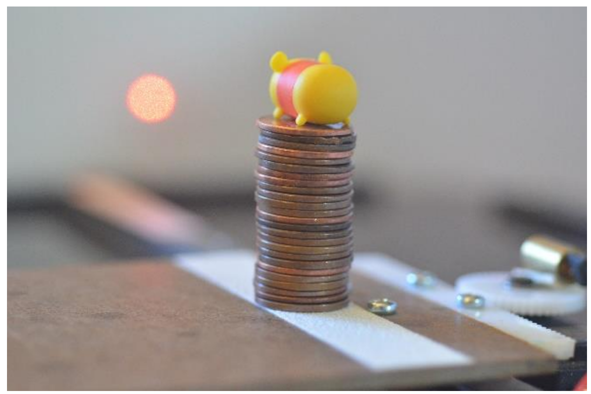
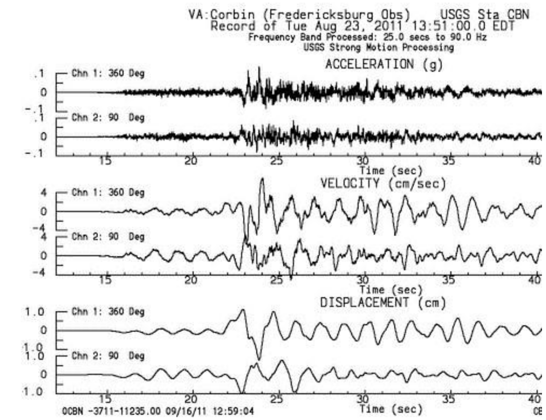
Designing Earthquakes for a Low-Cost Shake Table

Session DI03 Tue, July 25, 8:50 AM
AAPT 2017 Summer Meeting

Fred Thomas, Robert Chaney & Marta Gruesbeck







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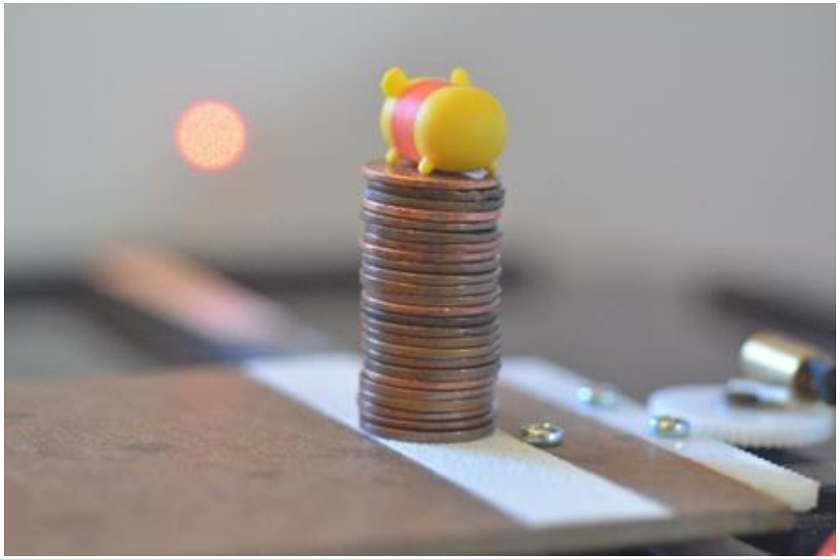
Build a Structure Which Can Survive a Richter Magnitude 5 Earthquake

Then ….

Design a Magnitude 4 Earthquake to

Destroy it



A 22-year STEM Collaboration

- Began in 1995 under a series of grants to Sinclair Community College from the National Science Foundation's Advanced Technological Education program
- Backgrounds in physics (Fred), math (Bob) and engineering (Marta)
- Working to develop brief activities which <u>respect the rigor and integrity of each discipline</u> while incorporating <u>common threads into all STEM disciplines</u>

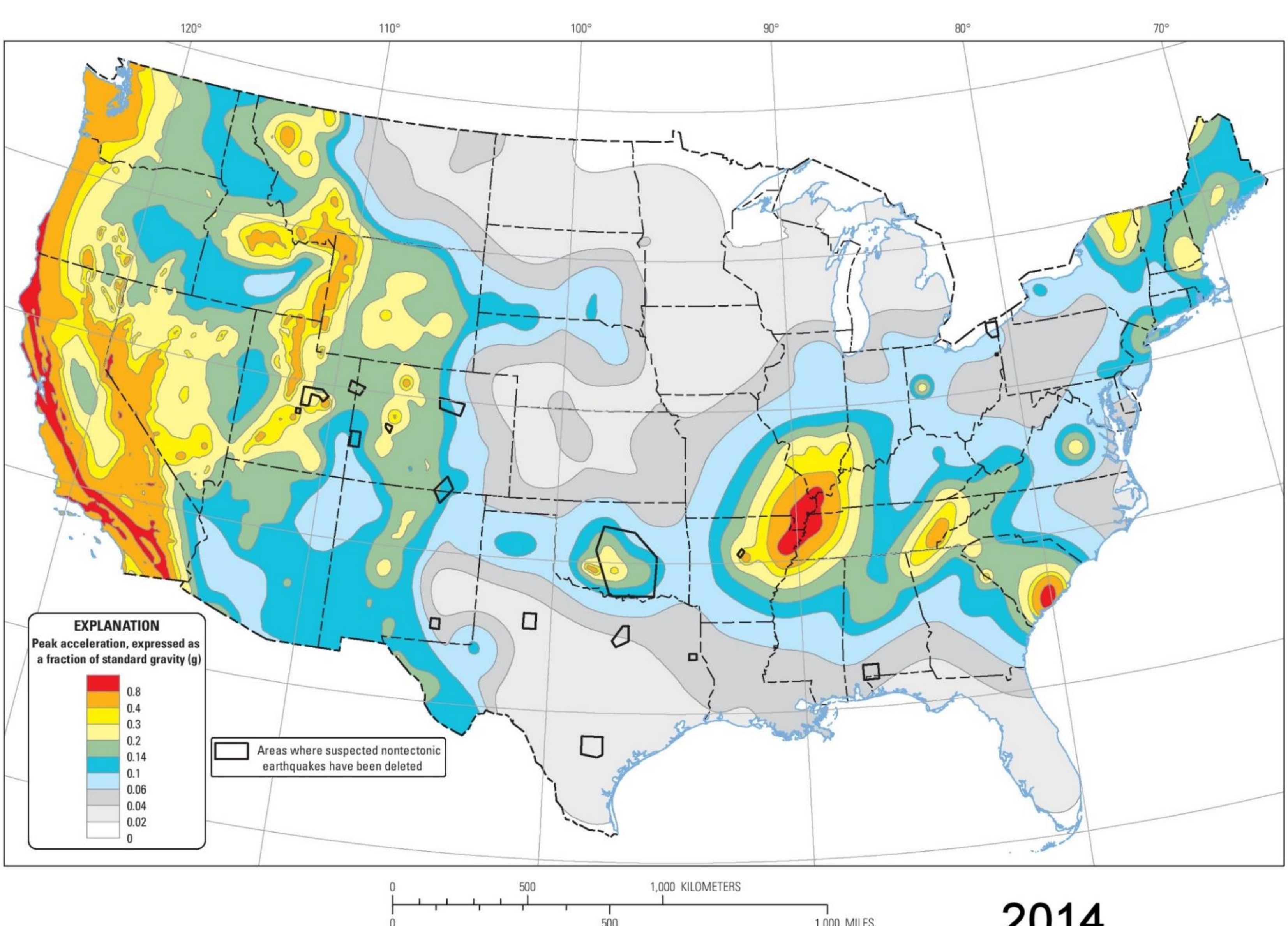
1. ***Algebraic thinking***, not just solving equations,
2. ***Key physics concepts***, such as position and acceleration,
3. ***Brief engineering-related tasks*** which apply rigorous math and physics, and
4. ***Immediate, authentic feedback.***

- Spun-Off to become an independent, 501(c)(3) non-profit
- Article coming in *The Physics Teacher* this winter

Earthquakes can engage learners in thinking more deeply about Position, Velocity, and Acceleration <u>and</u> about the connections and differences between science and engineering

Richter designed his original magnitude scale with the goal of <u>understanding</u> (and perhaps predicting) earthquakes.
He chose maximum <u>displacement</u> as his key measure of earthquake severity.

Engineering and construction standards have a goal of ensuring that buildings, dams, bridges and other structures are <u>safe, effective and affordable</u>.
Earthquake building codes are based on <u>acceleration</u> as the primary measure of earthquake danger.



2014

Two-percent probability of exceedance in 50 years map of peak ground acceleration

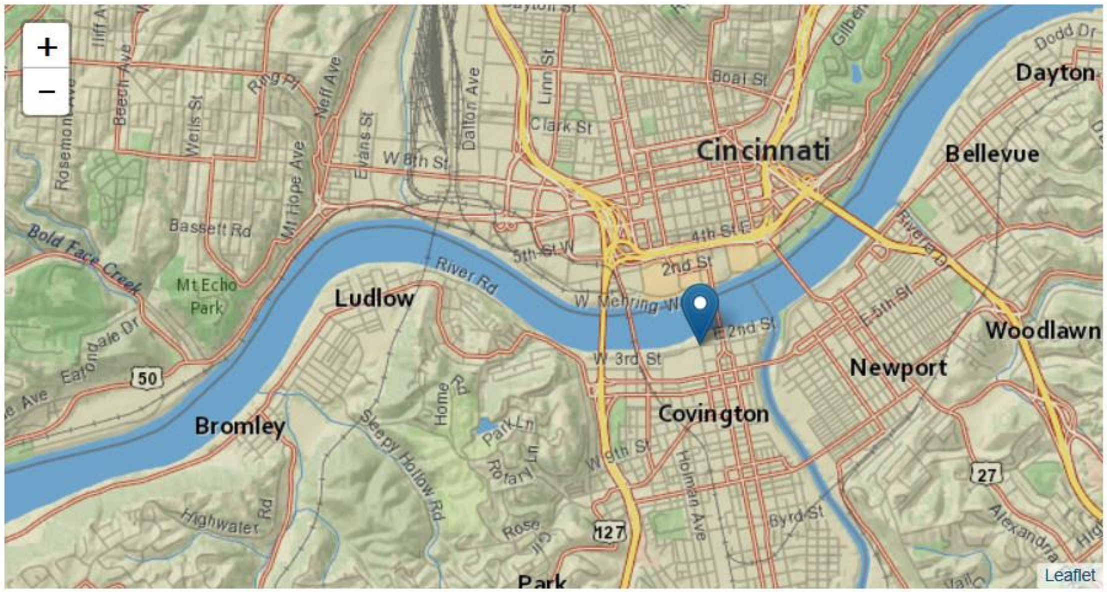
http://earthquake.usgs.gov/hazards/products/conterminous/2014/2014pga2pct.pdf

Site-adjusted, maximum considered earthquake (2% probability in 50 year) is 0.233 g or 2.28 m/s^2

Northern Kentucky Convention Center

Latitude = 39.090°N, Longitude = 84.512°W

Location



Reference Document

2015 NEHRP Provisions

Site Class

D (default): Stiff Soil

Risk Category

IV e.g. (Essential Facilities)

Edit | + New | Print | Download | Upload

S_S =	0.146 g	S_{MS} =	0.233 g	S_{DS} =	0.156 g
S_1 =	0.077 g	S_{M1} =	0.185 g	S_{D1} =	0.124 g

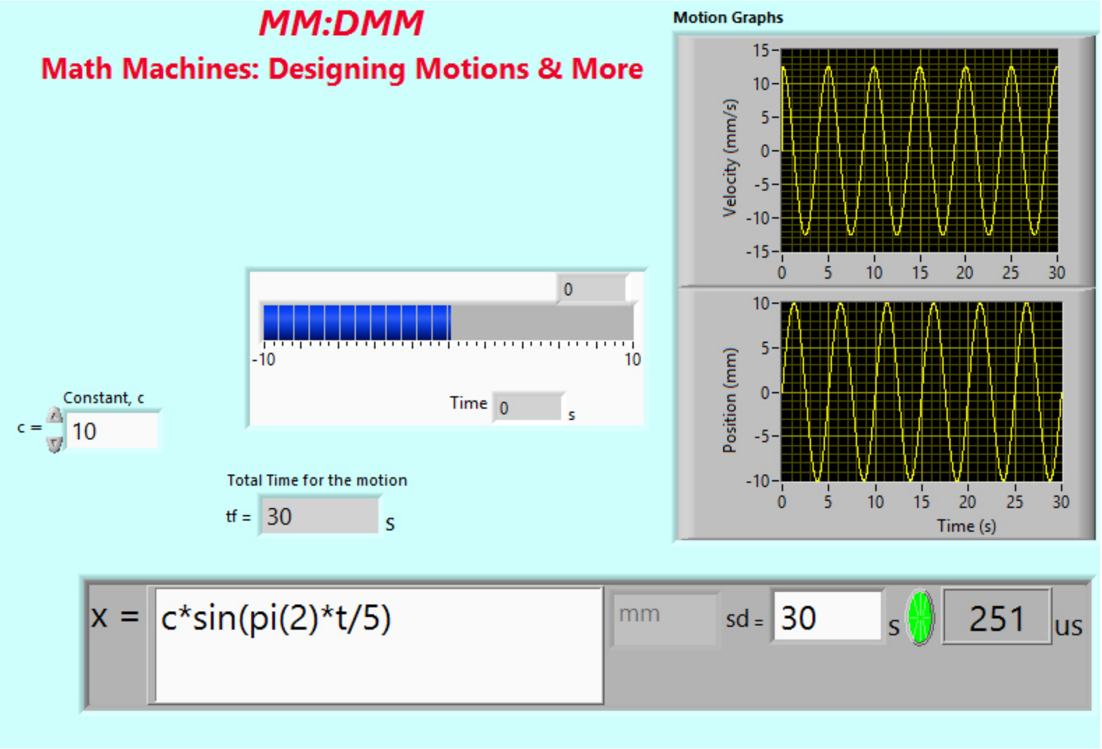
http://earthquake.usgs.gov/designmaps/us/application.php

Key Tool #1: An Algebra-Based User Interface to Control Motion

Distributed as a free LabVIEW executable, the interface allows learners to program the physical motion of either a servo or stepper motor with Excel-like algebraic formulas

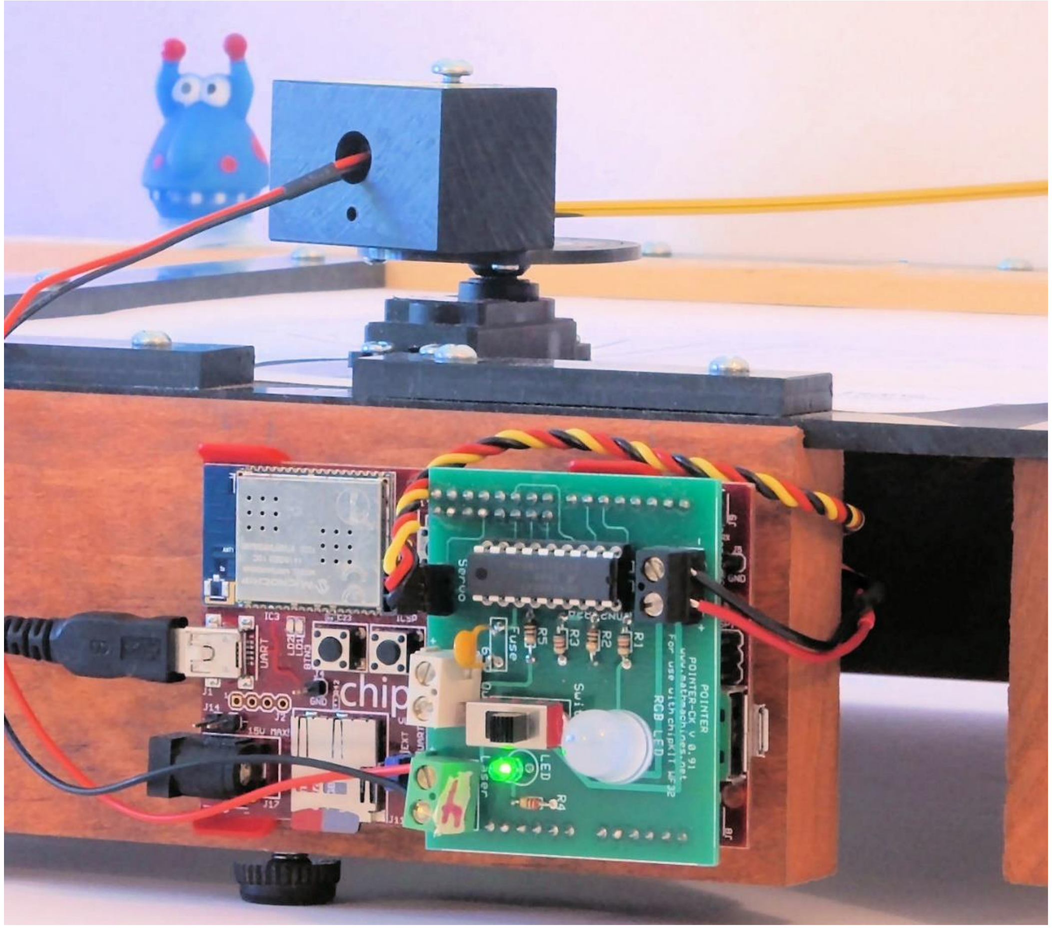
Functions can be specified as either x = f(t) or v = f(t).

Inputs can also be in the form of data sets, such as seismometer measurements of actual earthquakes



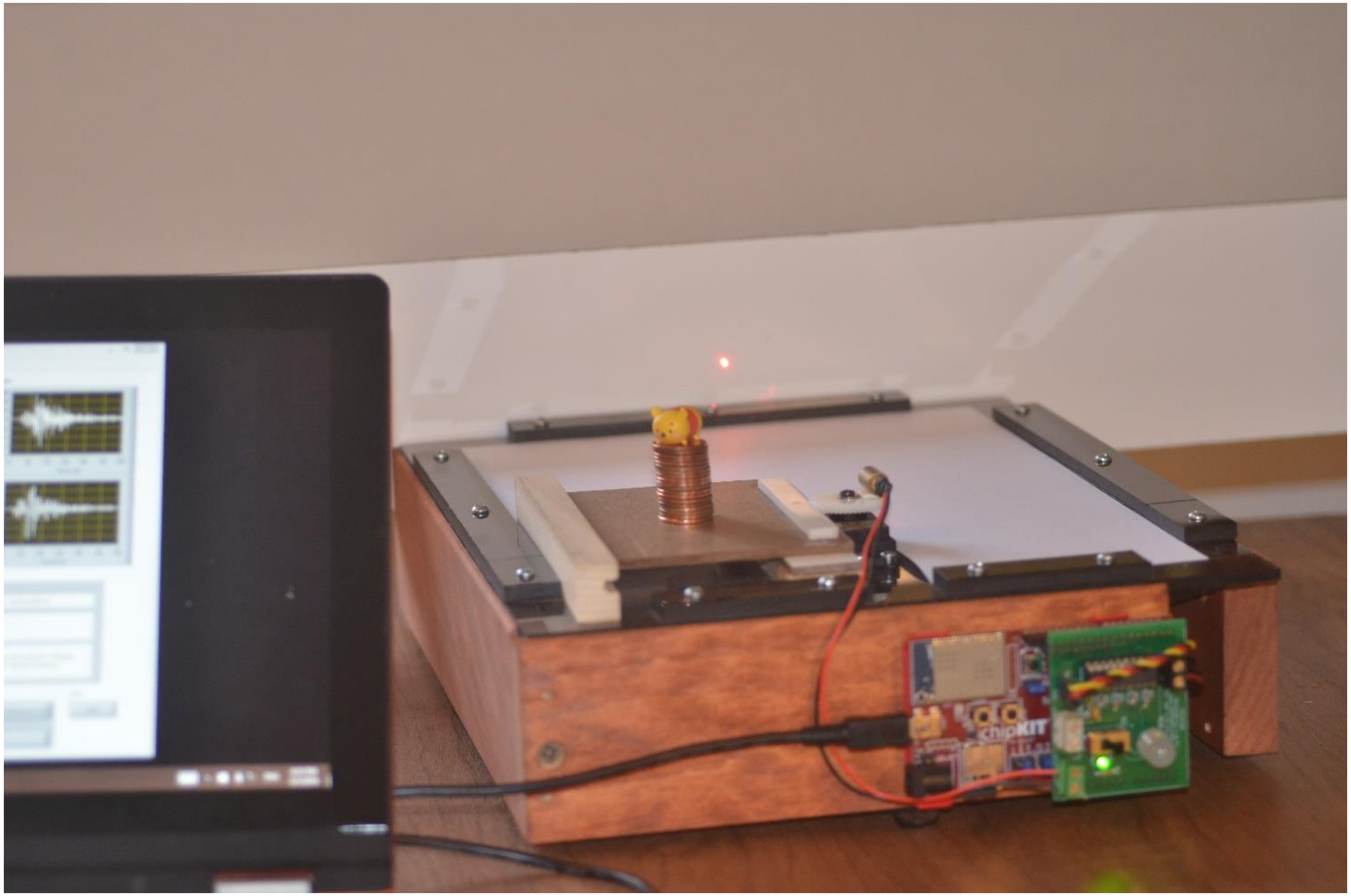
Key Tool #2: An Arduino-Style Board with SD Card

We use a Digilent chipKIT WF32 with a micro-SD card, a shield and a sketch that let users store and rapidly play very large sets of position (or RGB color) data.

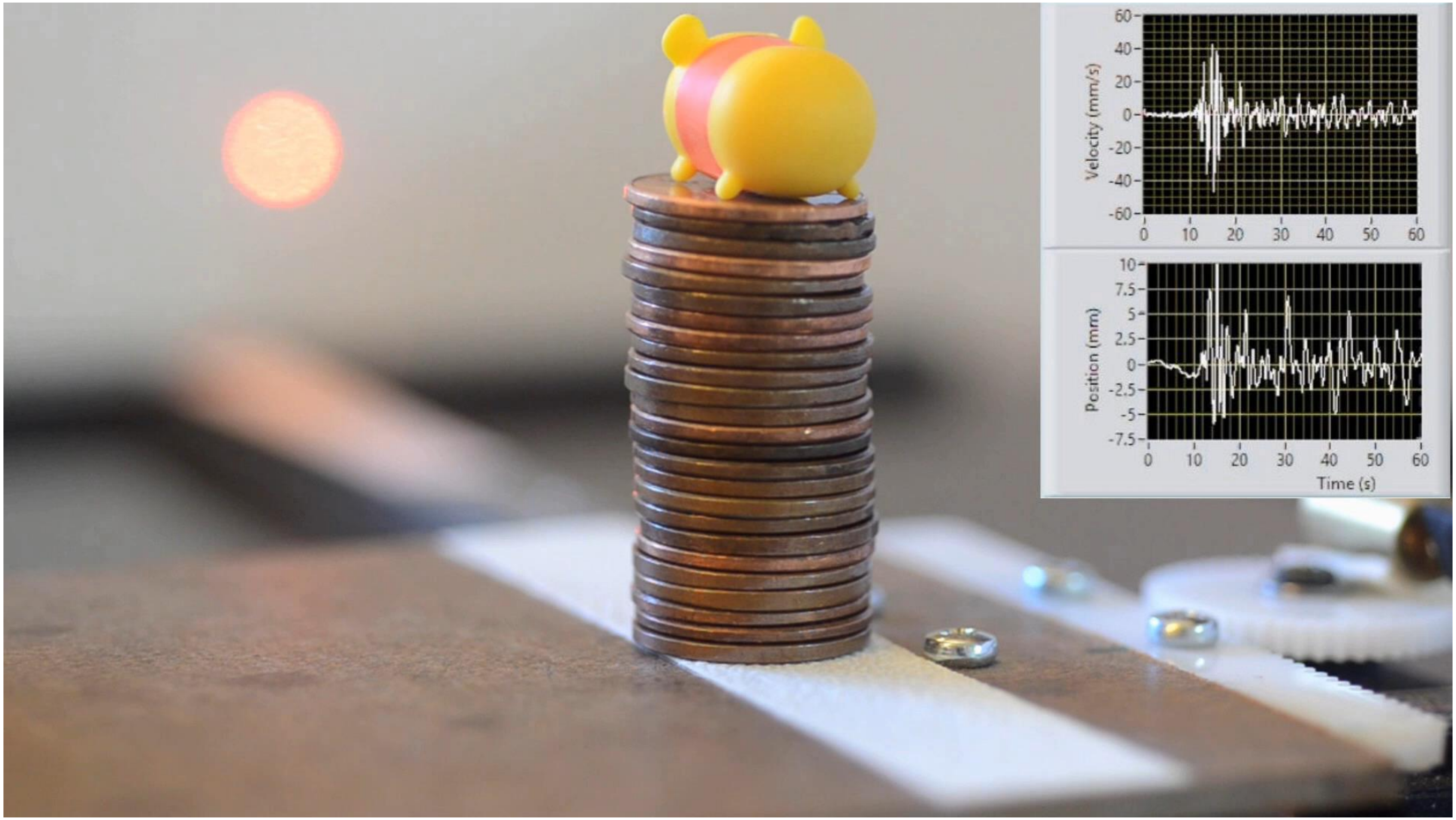


Key Tool #3: Flexible, Low-Cost Hardware

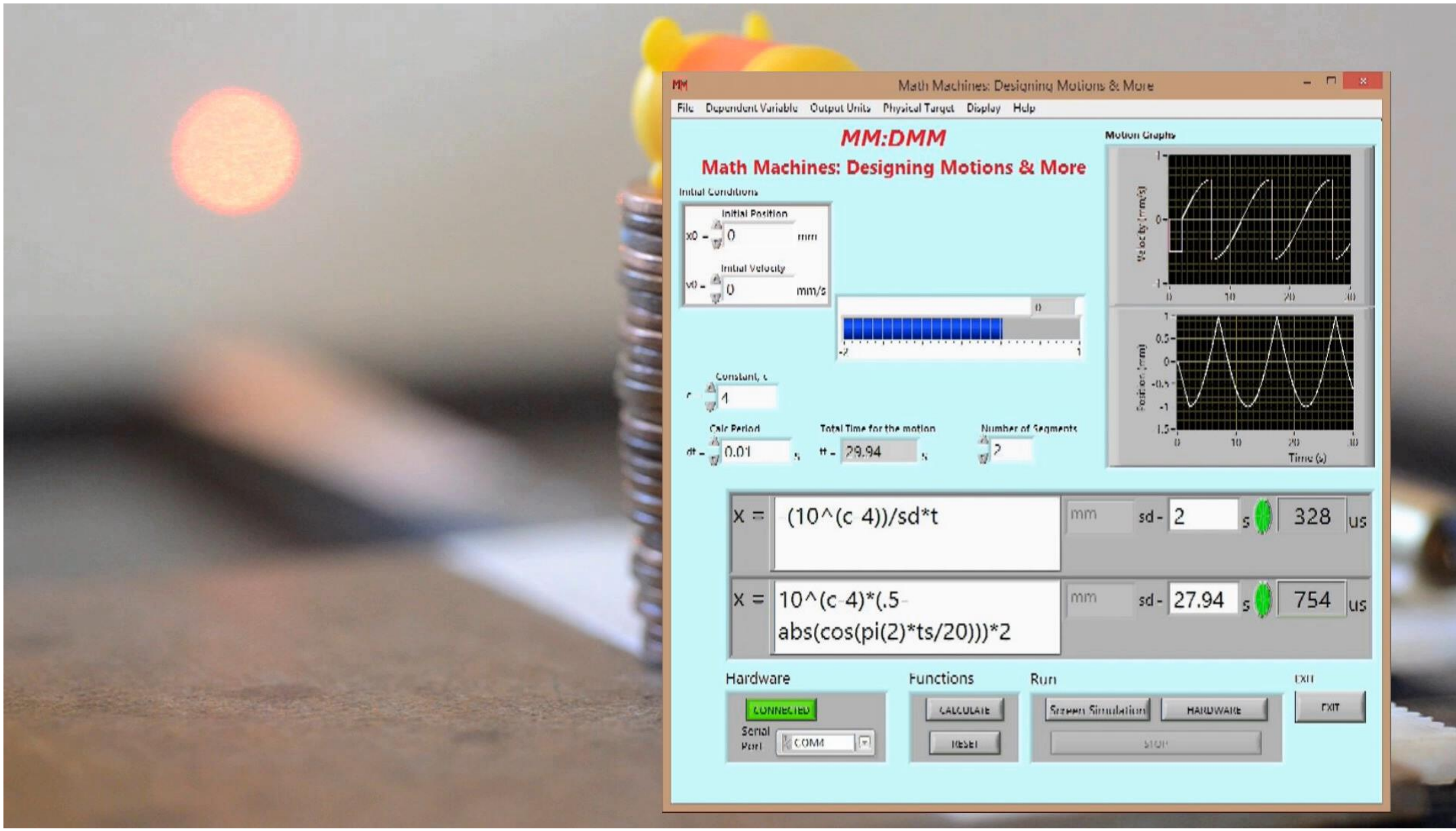
For earthquake activities, we use a rack and pinion system to drive a movable platform with a servo motor



Build a pile of pennies which can withstand a Magnitude 5 earthquake



Design a Magnitude 4 earthquake to knock over that same pile of pennies



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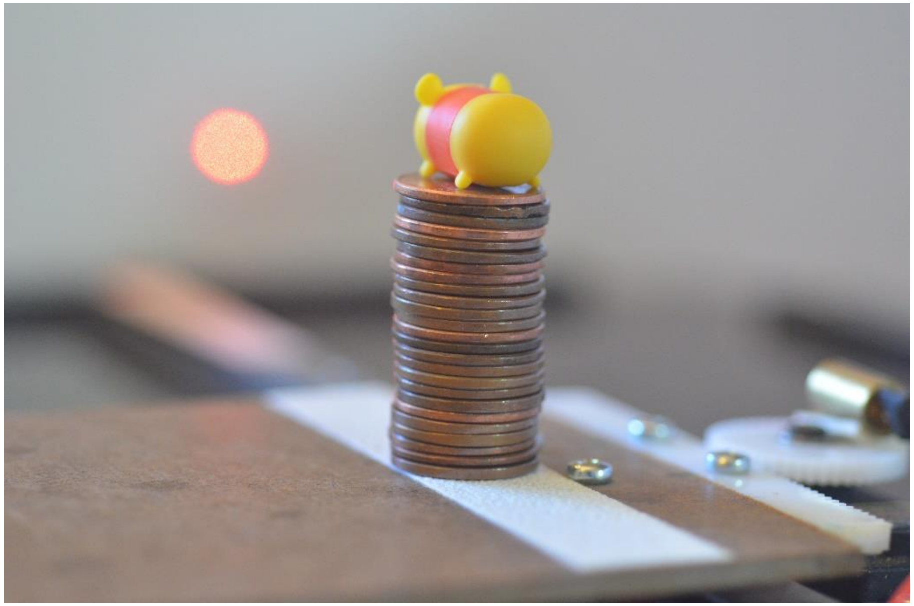
Poster PST2B23 Tue, July 25, 5:00-5:45 pm



Watch for our article in
The Physics Teacher

"Math Machines: Using Actuators in Physics Classes"

YouTube Videos:
Designing Earthquakes: Magnitude
Designing Earthquakes: Beyond Just Magnitude

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