Sam Reid, Ph.D.
University of Colorado Boulder

PhET Interactive Simulations

- Founded in 2002 by Boulder's Nobel Prize Physicist Carl Wieman
- 120+ interactive simulations in Flash, Flex, Java, **JavaScript**
- **Free and Open Source, no login/account required to use**
- 200,000,000 launches
- Math, Physics, Biology, Earth Science, Chemistry, etc.
- Highly interactive, gamelike simulations
- Student = Scientist

Sim Demos

- Energy Skate Park: Basics
  - Open-ended, flexible, fun
  - http://phet.colorado.edu/en/simulation/energy-skate-park-basics
- Molecule Shapes
  - Visually engaging, scientifically accurate
  - http://phet.colorado.edu/sims/html/molecule-shapes/latest/molecule-shapes_en.html
- Build an Atom
  - Games
  - http://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html
- Bending Light
  - http://www.colorado.edu/physics/phet/dev/html/bending-light/1.0.0-dev.8/bending-light_en.html

Process

- Idea (from teachers, community, etc.)
- Design + Implement
- Student interviews
- Code review
- Thorough QA Testing on 18 platforms
- Publish
- Maintenance

Implementation

- The simulation
- Model support: Axon
- View support
  - Scene graph, input events, rendering: Scenery
  - User interface components (checkboxes, sliders, etc): Sun
  - Custom interface (water faucets, gauges): Scenery-phet
- Framework: Joist
- Build tools: Chipper
  - Builds a single HTML file (inlines all images/audio)
    - One http request
    - Easy for teachers to download and run, no server necessary

The Scene Graph: Scenery

- Configurable hit areas for touch devices
  - http://phet.colorado.edu/sims/html/beers-law-lab/latest/beers-law-lab_en.html**?showPointerAreas**
- Render with SVG/Canvas/WebGL (partial support)
  - http://localhost:8080/acid-base-solutions/acid-base-solutions_en.html?ea&brand=phet&**rootRenderer=canvas**&screens=1

```
var node = new ProtractorNode({renderer:'canvas'});
```

- Excellent performance all the way back to iPad2
- Fine control over the UI presentation on every platform
- Fuzz testing: http://localhost:8080/acid-base-solutions/acid-base-solutions_en.html?fuzzMouse
- Screen capture: http://localhost:8080/wave-on-a-string/wave-on-a-string_en.html?ea&brand=phet&screenshot

Internationalization

- Balancing Act: Arabic:
  - http://localhost:8080/balancing-act/balancing-act_en.html?ea&brand=phet&**locale=ar**
- Under Pressure: Japanese:
  - http://localhost:8080/under-pressure/under-pressure_en.html?ea&brand=phet&**locale=ja**
- Build an Area: Double
  - http://localhost:8080/area-builder/area-builder_en.html?ea&brand=phet&**stringTest=double**
- String test:
  - http://localhost:8080/acid-base-solutions/acid-base-solutions_en.html?**stringTest=Thanks Quick Left!**

Accessibility

- http://phet.colorado.edu/en/about/accessibility
- Forces and Motion: Basics
  - http://www.colorado.edu/physics/phet/dev/html/forces-and-motion-basics/1.1.5-dev.4/forces-and-motion-basics_en.html?screens=1
- Faraday's Law
  - http://www.colorado.edu/physics/phet/dev/html/faradays-law/1.0.1-sonification.8/faradays-law_en.html

Interoperability

- Beaker sim
- Remove controls
  - http://localhost/beaker_en.html?ea&together.values=%7B"beaker.beakerScreen.soluteSelector.visible":false
- Change layout
  - **"beaker.beakerScreen.soluteSelector.rotation":1.58**
- Mirror
- Chart
- Data

RequireJS plugins

```
// modules
var inherit = require( 'PHET_CORE/inherit' );
var PropertySet = require( 'AXON/PropertySet' );
var ObservableArray = require( 'AXON/ObservableArray' );

// strings
var airString = require( 'string!BENDING_LIGHT/air' );
var diamondString = require( 'string!BENDING_LIGHT/diamond' );

// images
var image = require('image!BENDING_LIGHT/laser.png');

// audio
var audio = require('audio!BENDING_LIGHT/powerup');

// mipmaps
var protractor = require('mipmap!BENDING_LIGHT/protractor.png');
```

Example Sim – implementation details

- http://localhost:8080/example-sim/example-sim_en.html?ea&brand=phet

- Code examples in IDEA

Kick the tires

- http://phet.colorado.edu
- https://github.com/phetsims/
- https://twitter.com/phetsims
- http://bit.ly/phet-development-overview

- reids@colorado.edu
- https://twitter.com/sam6reid

Questions?