Using Interactive Java-free web-based interactive simulations in Astro 101 labs

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Introduction

Often Astronomy 101 courses include an associated indoor laboratory, which forces instructors to create indoor laboratory activities that allow students to make observations, make measurements, and analyze data as well as visualize key concepts. Several of our labs utilize web-based lab experiences that make use of interactive simulations (originally **Java applets** on webpages).

Initially, the **Java applets** were either linked from other websites or locally developed and embedded into the laboratory website. Starting in 2013 Java security fixes started making it harder and harder to run the applets. From 2014-2016, a student programmer rewrote most of the applets in **JavaScript and HTML 5**. This poster discusses the difficulties of creating the Java-free applets and how to use the applets in lab activities.

Please find the Astro 101 applets online at http://physics.unm.edu/Courses/Rand/applets [1].

Background

The University of New Mexico (UNM) is public metropolitan university & the state flagship university:

- Academic rating: 64 (in the Princeton Reviews)
- Annual enrollment: 20,000 students
- Average student age: 24
- Large fraction of first generation college students.
- Student population is 40% Hispanic and 5% Native American. Most students are commuters.

Astronomy 101 course

The Astronomy 101 (ASTR 101) course is the most popular Physics and Astronomy Department's course (1600 students/year)

- Fulfills in part general education science requirement.
- Lecture → one-semester tour of the universe
- Associated laboratory is optional.
- Both lecture and lab each have one online section.
- 35% of ASTR 101 students take online version
- 41% of ASTR 101 students take lab
- 19% of ASTR 101 lab students take it online

The Astronomy 101 Laboratory Course

- The Astronomy lab consists of 15 weekly lab activities and two evening observing projects
- The weekly lab activities in the face-to-face sections are done on a proprietary website in the astronomy lab room. Student groups of two complete the online lab forms and print out their lab report before they leave.
- In the online sections go through the online Blackboard materials including the simulations and then complete an online quiz as their lab report.

HTML5/JavaScript Applet	Associated Astro Lab
Calculate your weight	Planet Properties
Kepler's 2nd Law	Kepler's Laws
Kepler's 3rd Law	Kepler's Laws
Retrograde Motion	Kepler's Laws
Inverse Square Law for Light	Photometry
Eclipsing Binary Light Curve	Binary Stars
Spectroscopic Binary	Binary Stars
Simulated Evolution of a Cluster HR Diagram	Star Clusters
Milkyway Viewer	Galaxies

Table 1: List of HTML 5 / JavaScript Applets

Trouble with Java (timeline)

Initial Conditions (2012):

- Proprietary websites, locally developed Java applets, and linked Java applets work both in Astronomy lab room and in online lab section.
- Students have little difficulty running Java applets in Internet Explorer and Firefox.
- Compatibility issues with other browsers

Conditions begin to change (2013):

- Adobe starts to address security flaws in Java drivers. Java Applets will not run in new default security mode in Java.
- Security mode in Java Driver must be set to lowest setting **(medium)** to run the applets (see below for other solution).
- Students in Astronomy lab room have no difficulty but online lab students need substantial help from faculty and tech support to run the applets.

Conditions deteriorate (2014)

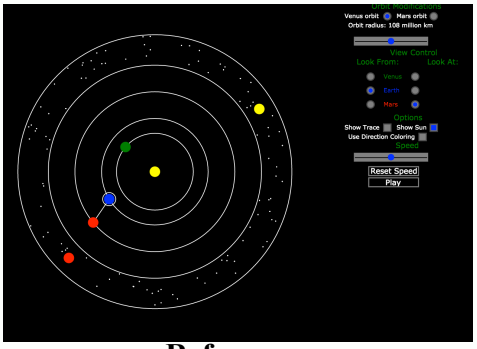
- New versions of Java driver eliminate medium security setting (only have high and very high settings).
- Alternate solution of using "Exception site list" is now only solution. Every server hosting a Java applet must be listed for the applet to run.
- Alternate applets tested and made available to lab instructors. In some cases, suitable alternate applets not available.
- Java applets run in Astronomy lab room > 90% of the time; Students in online lab running applets on their own or non-Astronomy-lab school computers all need help to run the applets.
- A small but growing number of online lab students cannot get applets running and must complete alternative assignments instead.

Figure 1. Retrograde Motion Applet

http://physics.unm.edu/Courses/Rand/applets/retrograde.html

This applet is used in Kepler's Law lab. Note that the planets are moving counterclockwise so that the Earth (blue dot) is overtaking Mars (red dot). As the Earth passes Mars, Mar will appear to move backwards relative to the night sky (outer ring). The views and the orbital radii are adjustable. This enables students to hypothesize about the retrograde motion of Neptune and to check their hypothesis.

Based on a Java applet created by McGraw-Hill Companies.



References

[1] The applets presented here were created for the University of New Mexico Astronomy 101 laboratory. The current version of the applets coded by Kevin Dilts. The applets are accessible on the web, downloadable, and free to use but if you use them, please acknowledge Kevin Dilts and the University of New Mexico.

Time for action (2014-2016)

Department decides to create new versions of the local and linked applets for Astronomy 101 lab needs that can be

- accessed both in the lab room and by online lab students.
- Can work in most commonly used browsers (Chrome, Firefox, and Safari)

Project took 18 months with student programmer

- HTML 5 & JavaScript chosen to avoid Java security & browser compatibility issues.
- Professional Applet developers wanted $10k+ per applet, so student programmer engaged to program applets

Difficulties: Student programmer had to learn

- How to do animations in JavaScript
- The relevant physics and Astronomy (R. Rand).

Figure 2. Inverse Square Law for Light

http://physics.unm.edu/Courses/Rand/applets/luminosity.html

This applet is used in an introduction to Photometry lab. The photometry simulator has 3 stars, each with a luminosity 10x greater than the star to the left. The cursor is used as a light sensor that records a measurement when the left mouse button is clicked. The results are plotted on Luminosity vs. radial distance graphs where the 1/r and $1/r^2$ curves are shown. The students use their plotted results to see which of the two curves better represents the data. A randomizer is used to create noise that is more noticeable at smaller intensities. Students are also asked to compare the luminosities of the dimmest and brightest stars at the same r.

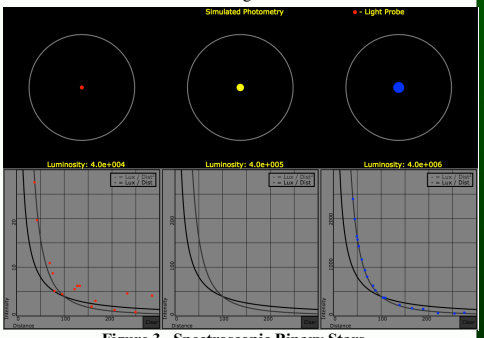


Figure 3. Spectroscopic Binary Stars

http://physics.unm.edu/Courses/Rand/applets/spectroscopicBinaries.html

This applet is used in the Binary Stars lab. Many parameters including the masses of the two stars, the angle of view as seen from Earth, and eccentricity of the orbits can be varied. The example below is for the elliptical orbits of two stars with mass ratio of 2:1. The applet is used to see what happens to the period and the ratio of a^3/p^2 for different mass ratios (should = sum of star masses). Adjusting the mass ratio values to 100:1 can be used to help visualize the difficulties of searching for extrasolar planets.

Based on a Java applet by Terry Herter at Cornell