Developing and Using Simulations to Support Physics Students

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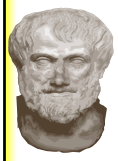
Hull Workshop March 2006

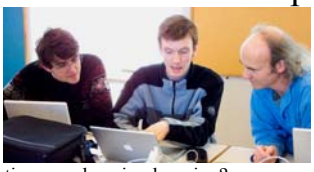
Study?

Students thinking critically? Brain on?



Constructivist — Generative - help to make own links — Spoon-fed?

Can simulations help?



- Facilitating or enhancing learning?
- Structured exploration, almost constructivist, generative
- Showing use of mathematical model of reality
- Visualisation
- No other way to calculate - numerical integrations

- As part of overall learning and teaching programme
- Easily customise others' sims for local needs

Example? - Young's slits

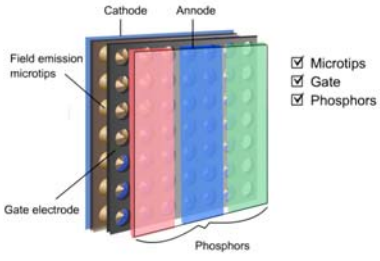
- Reality, explanations, diagrams
- Rays, waves, interference
- Phasor concept, phasor representation
- Simulated reality
- graph results
- Questions, checks of model

When monochromatic laser light is shone on a pair of double slits, the pattern shown at the right is produced on a distant screen.

What would happen to the pattern if one of the slits were covered?

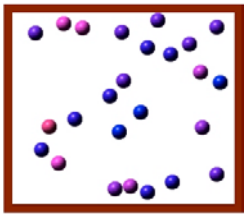
Fig. 3: A problem in physical optics (from Wosilait et al.,)

Animated Picture



Tom Edwards

Ideal Gas Model, Physics 2000, Java



Java code, freely available

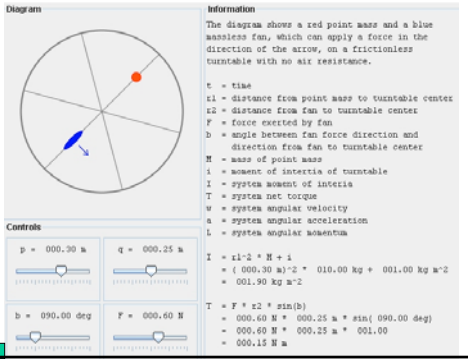
Central Forces - Physics 2000 Java

... the Colorado University's example of the basic interaction of electrostatic forces is possibly the most useful and exciting example I have seen yet. I could have watched it for hours!

Of course the ideas are very simple and hopefully everyone in the class will understand these ideas by now, but it is still a very useful visualisation to solidify any gaps in an important mental exercise that we should all have by now. It may be worth spending 2 minutes demonstrating at some point for the class in case some people still haven't checked it out.

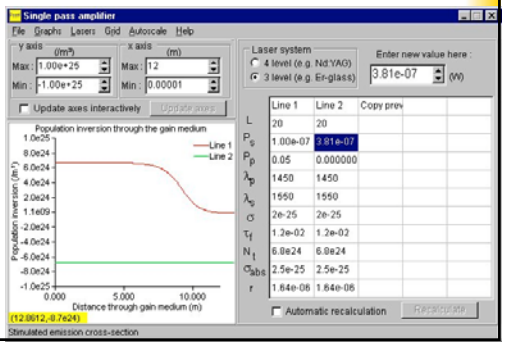
Also, I found it particularly useful as an astronomer, as another example of gravitational attraction in solar systems and in fact any large masses in free space. *2006 student email*

Edinburgh Applet



Erbium amplifier, St Andrews exe

Psst! Programmer Aly Gillies, St A

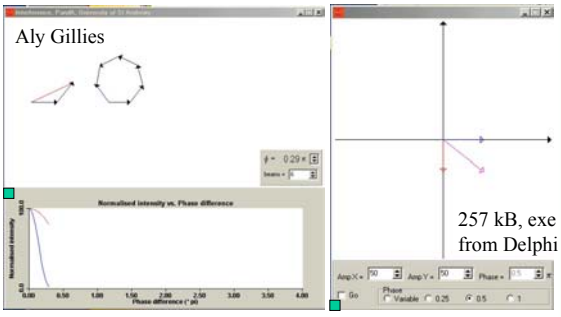


Where can I get them? And as what?

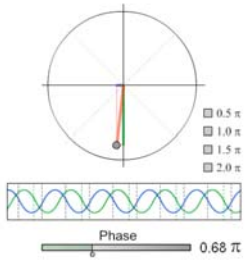
- HEA PSC Special Interest Group
- Edinburgh Physics Site
- Physlets
- Web somewhere ….
- Competent colleagues
- HEA PSC Projects

- exe files?
- Applets?
- Flash?
- Shockwave?

Visualisation of models

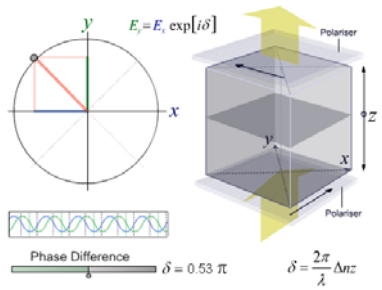


Flash: File Size: 6 kB



Phasor diagram just 6 KB in size.
Flash movie calculates the position of the phasor using the input from the slide bar.
The slide bar may be reused in many other animations.
Total time to completion: about 4 hours. Tom Edwards

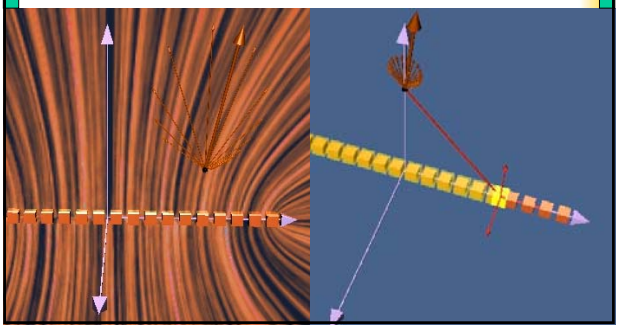
Flash: File Size: 17 kB



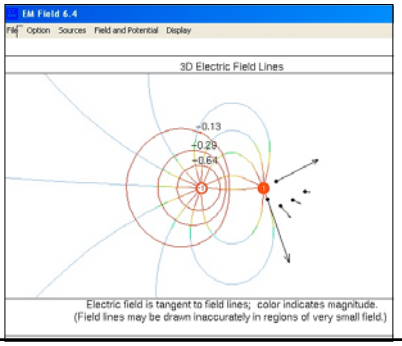
Same Phasor diagram enhanced for visualising a waveplate.
Flash movie calculates position of the phasor using input from the slide bar.
Slide bar also sets the position of the intersecting plane.
Total time to completion: about 2 hours extra. Tom Edwards

Total Internal Reflection, Guelph, Java

MIT Open CourseWare - Shockwave

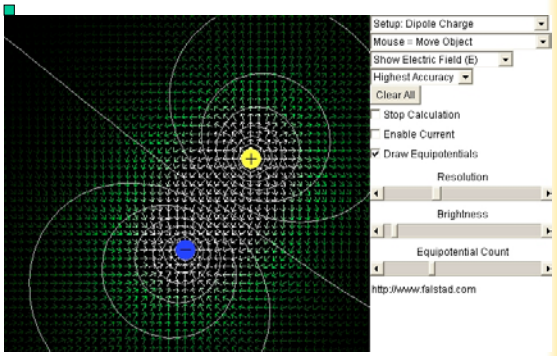


PAS EM Field - .exe file

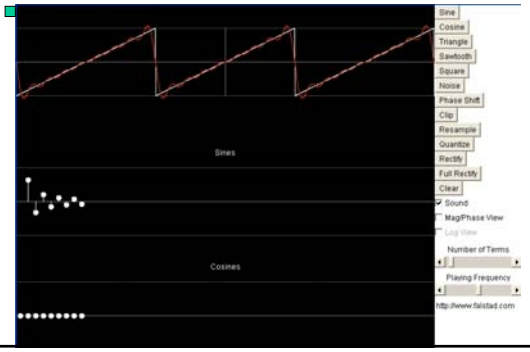


PAS EMfield6

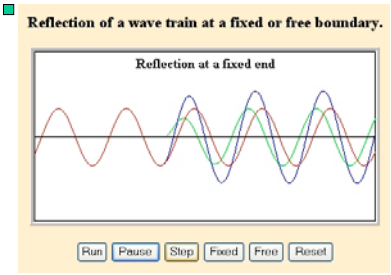
Java - Falstad



Fourier Series - Falstad applet



Building up a Standing Wave



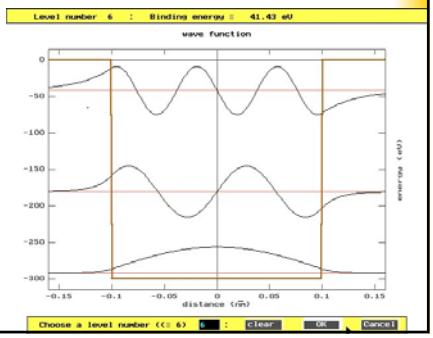
St Andrews implementation of Physlet (Davidson)

CUPS Quantum Mechanics

i) Particle in a box exercise, etc

www.wiley.co.uk/college/math/phys/cg/sales/CUPS.html

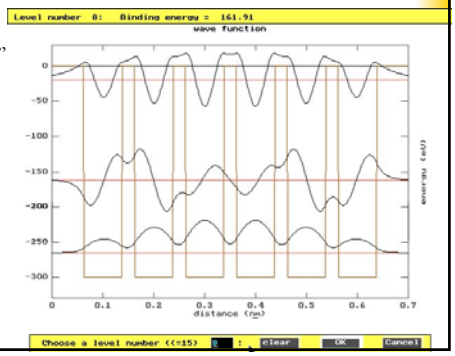
QM one of 9 topics



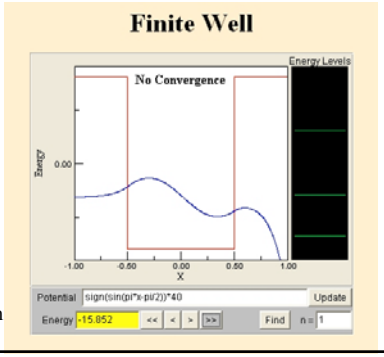
CUPS Quantum Mechanics

ii) Group "project"

e.g. particle in a periodic potential

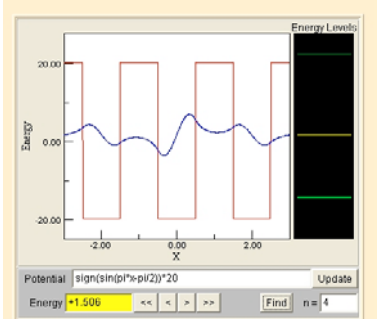


Physlet - QM - Java Physlet



Davidson

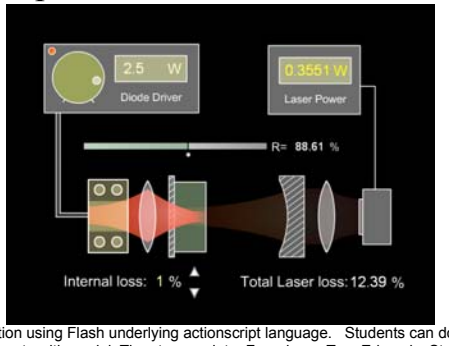
Physlet - more involved



Davidson

File Size: 20 KB

Experiment simulation, Flash



Simulation using Flash underlying actionscript language. Students can do virtual experiments with model. Time to complete: Four days. Tom Edwards, St A

What makes it work?

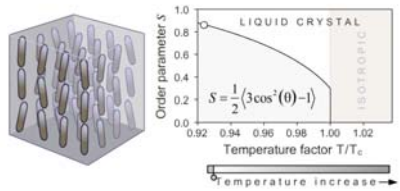
Meaningful interaction
Guided exploration
Appropriate simulation at the appropriate time
Working with the physics rather than the controls?
Need to do?

Face to face teaching & learning

Blended learning

Distance learning

Flash: File Size: 13 kB



More complex animation.

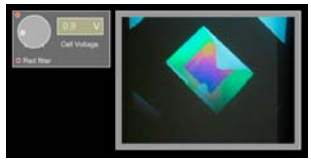
Time to complete: 1.5 days - note that many items were re-used in the course saving time later. Tom Edwards

Flash: File Size: 249 kB

Flash can import and control movie clips.

Time to complete (inc taking of movie) about 1.5 hours. Tom Edwards

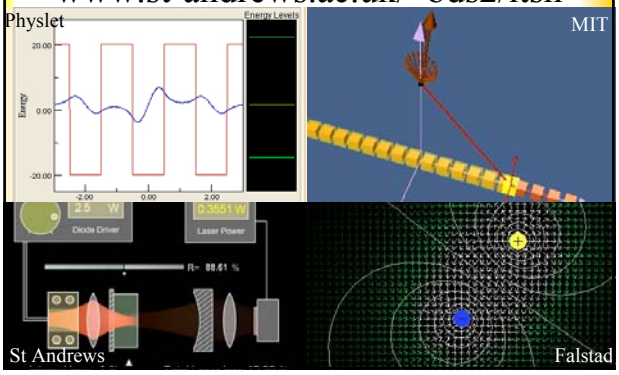
Flash: File Sizes: 305 kB (top) 525 kB (bottom)



Movie clips in Flash again now voltage control chooses frame to show

Tine to complete: 4 hours. Tom Edwards

www.st-andrews.ac.uk/~bds2/ltsn



Credits and Links

Aly Gillies and Tom Edwards are the technical experts at St Andrews who have contributed huge amounts to our use of simulations.

I acknowledge with thanks support from various funding bodies for our simulation development and use, including the LTSN, SHEFC, EPRSC, and our University.

I acknowledge the generosity of many others in making their simulations available to the world. I have tried to state the source of each simulation/animation on these slides. I link to their simulations (and others) at www.st-andrews.ac.uk/~bds2/ltsn/workshopsims.htm