ANTSY—Assembly for Nanotechnology Survey Courses

This nanoHUB "topic page" provides an easy access to selected nanoHUB educational material for a survey course on nanotechnology that is openly accessible.

We invite users to participate in this open source, interactive educational initiative:

- Contribute your content by uploading it to the nanoHUB. See "Contribute Content" on the nanoHUB mainpage.
- Provide feedback through the review system for the items you use on the nanoHUB. (Please be explicit and provide constructive feedback.)
- Let us know when things do not work by filing a ticket through the nanoHUB "Help" feature on every page
- Finally, let us know what you are doing and your suggestions improving the nanoHUB by using the "Feedback" section, which you can find under "DVD"

Thank you for using the nanoHUB, and be sure to share your nanoHUB success stories with us. We like to hear from you, and our sponsors need to know that the nanoHUB is having an impact.

Bucky Balls, Carbon Nanotubes, Graphene, Crystal Structures, and Lattices

Crystal Viewer

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The Crystal Viewer in ANTSY enables the interactive visualization different Bravais lattices, crystal planes, and materials (diamond, silicon, indium arsenide, gallium arsenide, graphene, and buckyball).

First-time use of the tool is supported by: Crystal Viewer Tool: First-Time User Guide

It is supported by a homework assignment in MS Word and Adobe PDF format.

Exercise: Crystal Lattices

Carbon Nanotubes and Graphene Sheets

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Carbon nanotubes and graphene ribbons made of the single element carbon have attracted significant interest in the nanotechnology research community. The CNTbands tool in ANTSY allows students to visualize the geometries of materials and study their electronic structure.

Additional Lectures / Learning Modules:

- Introduction to CNTbands
- Introduction to Carbon Nanotube Electronics
- Introduction to CNTbands

Closed Systems

Quantum Dot Lab

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Individual quantum dots can be created from two-dimensional electron or hole gases present in remotely doped quantum wells or semiconductor heterostructures. The sample surface is coated with a thin layer of resist. A lateral pattern is then defined in the resist by electron beam lithography. This pattern can be transferred to the electron or hole gas by etching or by depositing metal electrodes (lift-off process) that allow the application of external voltages between the electron gas and the electrodes. Such quantum dots are mainly of interest for experiments and applications involving electron or hole transport, i.e., an electrical current. The energy spectrum of a quantum dot can be engineered by controlling the geometrical size, shape, and strength of the confinement potential. Also, in contrast to atoms, it is relatively easy to connect quantum dots to conducting leads using tunnel barriers, which allows the application of the techniques of tunneling spectroscopy for their investigation. Confinement in quantum dots can also arise from electrostatic potentials (generated by external electrodes, doping, strain, or impurities).

Quantum Dot Lab in ANTSY computes the eigenstates of a particle in a box of various shapes, including domes and pyramids.

Lectures:

- Quantum Dots is a nano 101 introductory lecture that starts from particle-wave duality and explores the concepts of quantum dots.
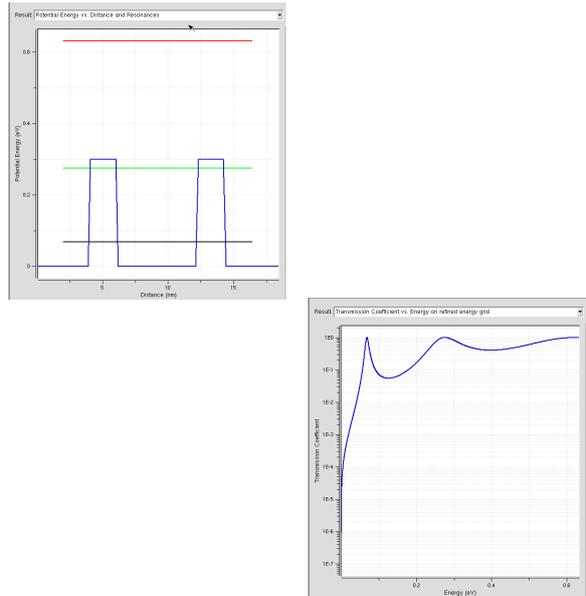
Exercises:

- Introduction to Quantum Dot Lab (by Lee, Ryu,and Klimeck)
- Quantum Dot Lab Learning Module: An Introduction (by Fodor and Guo)
- Quantum Dot Spectra, Absorption, and State Symmetry: an Exercise

Open Systems

Piecewise Constant Potential Tool
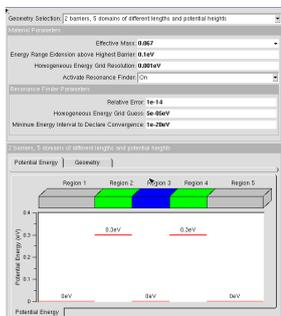
The Piece-Wise Constant Potential Tool in ANTSY allows users to calculate the transmission and the reflection coefficient of arbitrary five, seven, nine, eleven and 2n-segment piecewise constant potential energy profile. For the case of a multi-well structure, it also calculates the quasi-bound states. Thus the Piecewise Constant Potential Tool can be used as a simple demonstration tool for the formation of energy bands. Other uses include: 1) in the case of stationary perturbation theory, as an exercise to test the validity of the first-order and the second-order correction to the ground state energy of the system due to small perturbations of the confining potential, and 2) as a test of the validity of the Wentzel–Kramers–Brillouin (WKB) approximation for triangular potential barriers.

Exercises:

- Quantum-Mechanical Reflections: an Exercise
- Double-Barrier Case: An Exercise
- From 1 well to 2 wells to 5 wells to periodic potentials: an Exercise
- Energy Bands as a Function of the Geometry of the n-Well Potential: an Exercise
- Cosine Bands: an Exercise for PCPBT
- Quantum-Mechanical Reflections in Nanodevices: an Exercise
- Tunneling Through Triangular Barrier: an Exercise for PCPBT
- Stationary Perturbation Theory: an Exercise for PCPBT

Resonant Tunneling Diode Lab

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A barrier placed in the path of electrons will block their flow. If the barrier is too thin, however, the electrons can tunnel through it because of quantum mechanical effects. Furthermore, if two or more thin barriers are placed in close proximity, electrons will bounce between the barriers and, at certain resonant energies, begin to flow through the barriers.

The [Resonant Tunneling Diode Lab in ANTSY](#) allows users to experiment with this quantum mechanical phenomenon by controlling the number of barriers and their material properties and then simulate current as a function of bias.

Exercises:

- [Resonant Tunneling Diodes: an Exercise](#)
- [Finite Height Quantum Well: an Exercise for Band Structure](#)

About ANTSY Constituent Tools

The Assembly of Basic Applications for Coordinated Understanding of Semiconductors (ANTSY) has been put together from individual tools to provide educators and students with a one-stop-shop in semiconductor education. It therefore benefits tremendously from the hard work that the contributors of the individual tool builders have put into their tools.

As a matter of credit and ranking, simulation runs that are performed in the ANTSY tool are credited to the individual tools. We count the number of usages of the individual tools in the ANTSY tool set to measure the impact of ANTSY and to gather data we can use to improve the tool.

In the description above we do not refer to the individual tools since we want to guide the users to the composite ANTSY tool. We cite the individual tools here explicitly so they are being given the appropriate credit and on their respective tool pages, on which there are links to ANTSY.

[Crystal Viewer Tool](#), [Piece-Wise Constant Potential Barriers Tool](#), [Resonant Tunneling Diode Simulation with NEGF](#), [Quantum Dot Lab](#), and [CNTbands](#).

Additional Reading and Tools

[Tool-Powered Curricula](#)

(Image(/site/media/images/TPC_Teach_Learn3.png, 360px, class=align-right) failed - File not found) [ANTSY](#) is part of the series of [Tool-Powered Curricula](#)

Educators

Use the Tool-Powered Curriculum to augment existing courses and enhance the student learning. Use turn-key simulation tools to teach concepts, design, and optimization without

reading big manuals and installing software. Use it in your class room or for student assignments such as homework's or projects. ABACUS and AQME are tools which pull together many different nanoHUB tools into a single interface and are augmented with homework and project assignments. Solutions to homework assignments are available to educators upon request.

"… and more": Augment your class though interactive lectures from leading researchers providing tool tutorials, nano101 and nano501 lectures. Use community-contributed homework and project assignments in your class. Most lectures are available for interactive online viewing, as pdf downloads, and even podcasts.

Show a student and they will remember; involve them, and they will understand.

Students:

Enjoy using intuitive and user-friendly tools without software installation and reading massive manuals! You will be able to ask "what if?" questions and get answers rapidly to develop intuition and insight. [Register for a free nanoHUB account](#) or [log into your existing nanoHUB account](#) and begin teaching and learning with the tool powered curriculum.

[ABACUS—Assembly of Basic Applications for the Coordinated Understanding of Semiconductors](#)

(Image(/site/media/images/ABACUS_Small.png, 360px, class=align-right) failed - File not found) The curriculum entitled [Introduction to Semiconductor Devices](#) is powered by the tool [ABACUS](#). [The ABACUS powered curriculum](#) is designed to enhance the learning experience of students in existing classes on semiconductor devices in Electrical Engineering curricula. [ABACUS](#) is an assembly of different nanoHUB tools that range from crystals, bandstructure, pn junctions, and transistors.

[The ABACUS powered curriculum](#) is a curated page that provides easy access to a variety of different homework and project assignments that are relevant for the teaching of semiconductor devices. Educators can request access to homework solutions. Any community members are encouraged to contribute content to the nanoHUB. We encourage you to alert the authors of the curated page to your contribution for possible inclusion.

[AQME—Advancing Quantum Mechanics for Engineers](#)

(Image(/site/media/images/AQME_Small4.png, 360px, class=align-right) failed - File not found) The curriculum entitled [Quantum Mechanics for Engineers](#) is powered by the [AQME](#) tool which is an assembly of tools we believe are useful in the teaching of introductory quantum mechanical principles in an electrical engineering or physics curriculum. Commercial semiconductor devices have become as small as a few tens of nanometers and understanding

basic quantum mechanical principles of quantization, bands, and tunneling are of critical importance.

[The AQME powered curriculum](#) is a curated page that provides access to a variety of different homework and project assignments that are relevant for quantum mechanical principles. Educators can request access to homework solutions. Any community members are encouraged to contribute content to the nanoHUB. We encourage you to alert the authors of the curated page to your contribution for possible inclusion.