By completing the Piece-Wise Constant Potential Barriers Tool Lab (PCPBT Lab) in *ABACUS - Assembly of Basic Applications for Coordinated Understanding of Semiconductors*, users will be able to understand a) the concept of quantum-mechanical transmissions and reflections, b) a double-barrier structure and the concept of quasi-bound states, and c) the formation of energy bands due to the interaction between the wells in a multi-well structure.

The specific objectives of the PCPBT Lab are:

<table>
<thead>
<tr>
<th>Physical Model</th>
<th>Mathematical Model</th>
<th>Computational Model</th>
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<tbody>
<tr>
<td>a) Introduce the concept of:</td>
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<tr>
<td>- Open systems</td>
<td>- Tunneling effect</td>
<td>- Formation of a bandstructure</td>
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<tr>
<td>- Quasi-bound states and resonant tunneling</td>
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b) Apply the transfer matrix approach for calculating:
- Transmission coefficient vs. energy
- Quasi-bound states in multiple-barrier structure
- Cosine energy bands for multiple-barrier structure

c) Validate PCPBT by running the examples provided

**Recommended Reading**

Users who are new to the analysis of open quantum systems, the concepts of transmission and
reflection coefficient (needed for the calculation of the current in a quantum-mechanical system), the concept of resonant or quasi-bound states and the operation of resonant tunneling diode, or the formation of energy bands in multiple-well structures should consult the following resources:


**Demo**

* Piece-Wise Constant Potential Barriers Tool Demonstration: Bandstructure Formation with Finite Superlattices


**Theoretical Descriptions**

* PCPBT Manual

* Piece-Wise Constant Potential Barrier Tool MATLAB Code

**Tool Verification**

Comparison of PCPBT Lab and Periodic Potential Lab

Piece-Wise Constant Potential Barriers Tool Demonstration: Bandstructure Formation with Finite Superlattices

**Examples**

1. Comparison of PCPBT Lab and Periodic Potential Lab

**Exercises and Homework Assignments**

1. Quantum-Mechanical Reflections: an Exercise

2. Double-Barrier Case: An Exercise

3. Quantum-Mechanical Reflections in Nanodevices: an Exercise
4. From 1 well to 2 wells to 5 wells to periodic potentials: an Exercise

5. Energy Bands as a Function of the Geometry of the n-Well Potential: an Exercise

6. Tunneling Through Triangular Barrier: an Exercise for PCPBT

7. Stationary Perturbation Theory: an Exercise for PCPBT

8. Cosine Bands: an Exercise for PCPBT


10. PCPBT: Problem Assignment for Asymmetric Barriers

**Solutions to Exercises**

Solutions to exercises will be provided only to instructors!

**Evaluation**

This test will assess the users conceptual understanding of the physical, mathematical and computational knowledge related to the calculation of transmission coefficients, resonant tunneling, and the formation of bandstructure in crystals.

**ABACUS: Test for PCPBT Lab**

**Challenge**

In this final challenge users will integrate what they have learned about tunneling through piece-wise constant potential barriers such as the double barrier structure in resonant tunneling diodes.

**Analytical and Numerical Solution of the Double Barrier Problem**