CAMP

Center for Active Learning of Microelectronics and Photonics

Context based educational Java Applets using consumer products

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Motivation

- Java Applet Technology :
  - Provides a new tool for the development of Interactive educational materials
  - Gives a feel and look of conducting experiments-Virtual experiments
  - Aids the sharing of online applets in a platform independent manner.
  - Provides for the development of effective instructional tools but **not a substitute for teaching**

Existing Conditions

- Many Existing Java Applets:
  - Lack to provide a reference for the context of the applet
  - Lack the system level, top-down approach prevalent in engineering
  - Fail to address of an audience with different backgrounds

➧ In short, lack the right educational methodology

➧ Hence sometimes fail to provide the intended motivation for learning

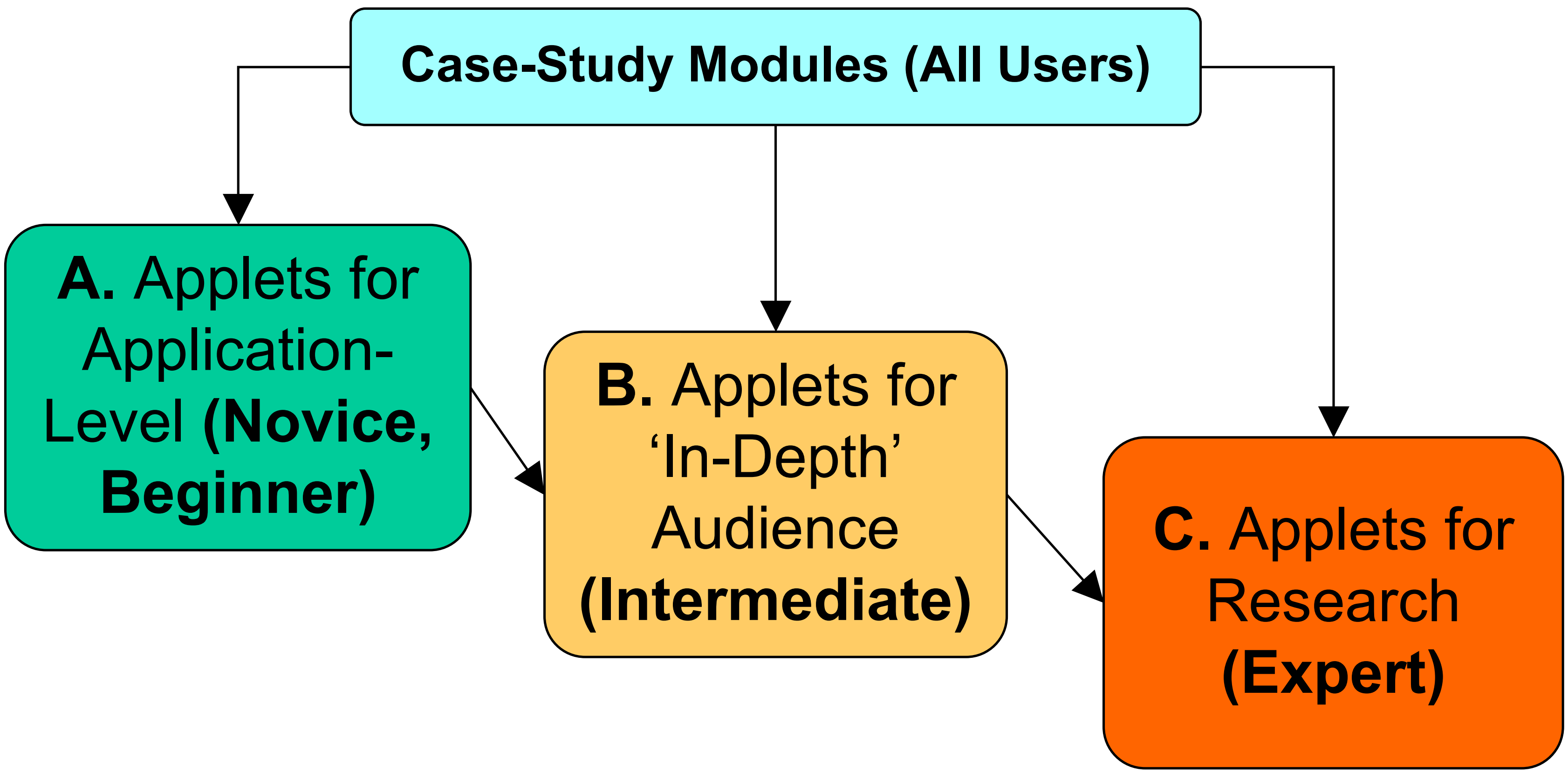
Our Educational Methodology

- Provides a context for the individual applets
  - Context must be ubiquitous and multi-faceted
  - Learners should be able to “identify with” the chosen context
  - Example : Bar Code Scanner

- Empower inquisitive visitors to the website
  - Promote self-learning
  - Allow learners to actively participate in the education process
  - Appeal to users regardless of their background

Overview of the Methodology

Java Courseware Pedagogy



Context Modules

Criteria for selecting the Context Modules

System providing the context

- Must be ubiquitous
  - **Like a popular consumer optoelectronic product**
    Example: Barcode Scanner
- Should a challenging intellectual appeal
- Should consist of component applets that will convincingly introduce the concepts in an apt manner
- Be attractive enough for inclusion in University and High school courses.

Using Context Modules is similar to using **Case-Studies** to teach science topics.
(Visit - http://ublib.buffalo.edu/libraries/projects/cases/case.html)

Context Modules

Context Modules in Microelectronics and Photonics

- Provides Context Module for Microelectronics and Photonics
  - **Include photonic devices: lasers, detectors, filters, etc.**
  - **Include semiconductor devices: amplifiers, digital electronics, etc.**
  - **Example: Consumer Electronic Products**
- Material is presented based on educational level

In summary the Top level applet:

- **Just requires user to be familiar with a consumer product.**
- **Shows the complete operation of the consumer product**
- **Provides the context for viewing the individual components**
- **Provides a menu for choosing educational level**
  - **The menus provided for viewing the component applets change depending on the education level chosen**

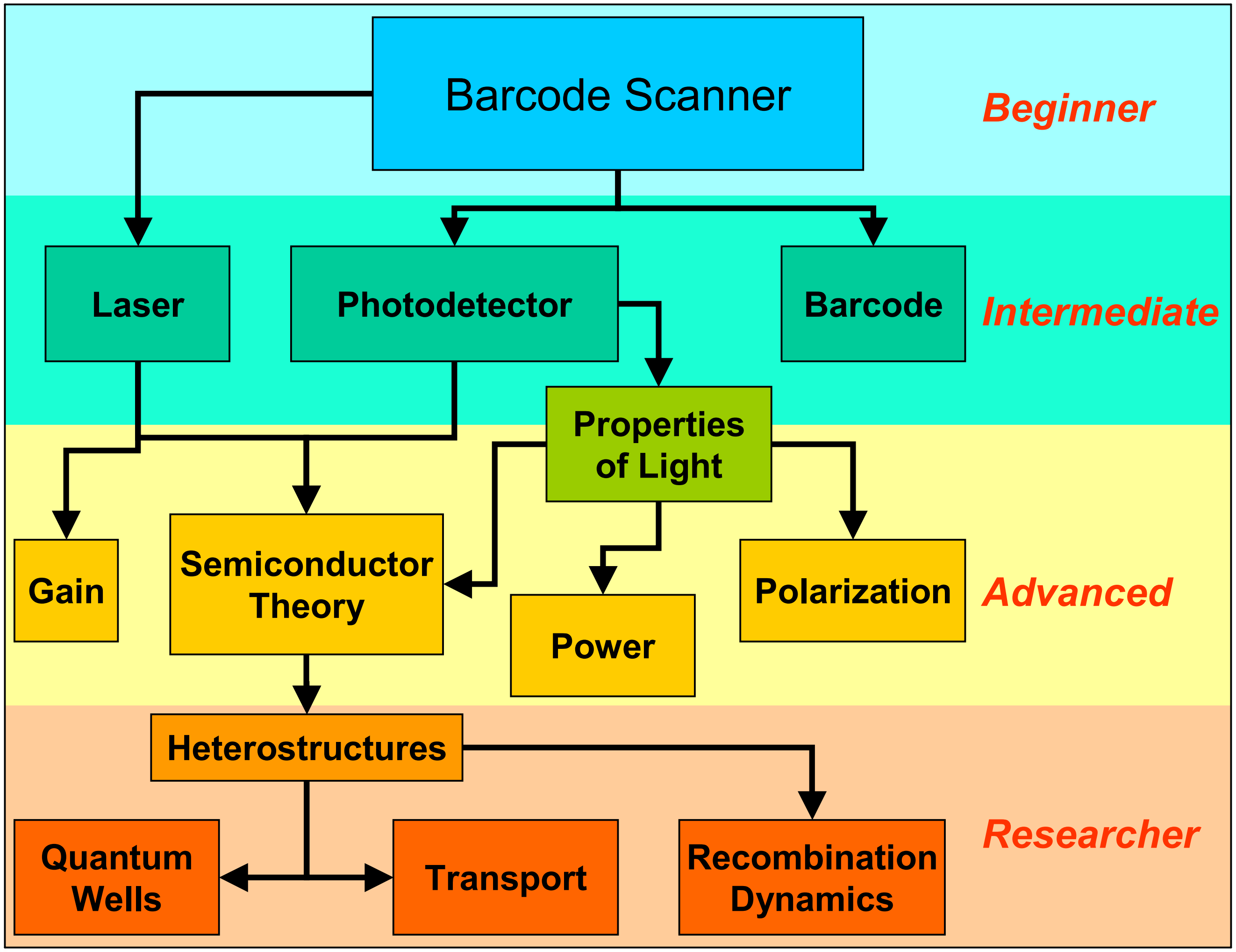
Context Modules

Examples of Context Modules

- Barcode Scanner (already implemented)
- Laser Printers
- Display Systems
  - Liquid Crystal Display
  - Field Effect Display
- Optical Scanners
- Distance and Speed Detection - LASAR
- Optical Non-destructive Testing
  - Thin Film Measurement System
  - Fault Detectors
- Optical Communication System
- Optical Chemical Detectors

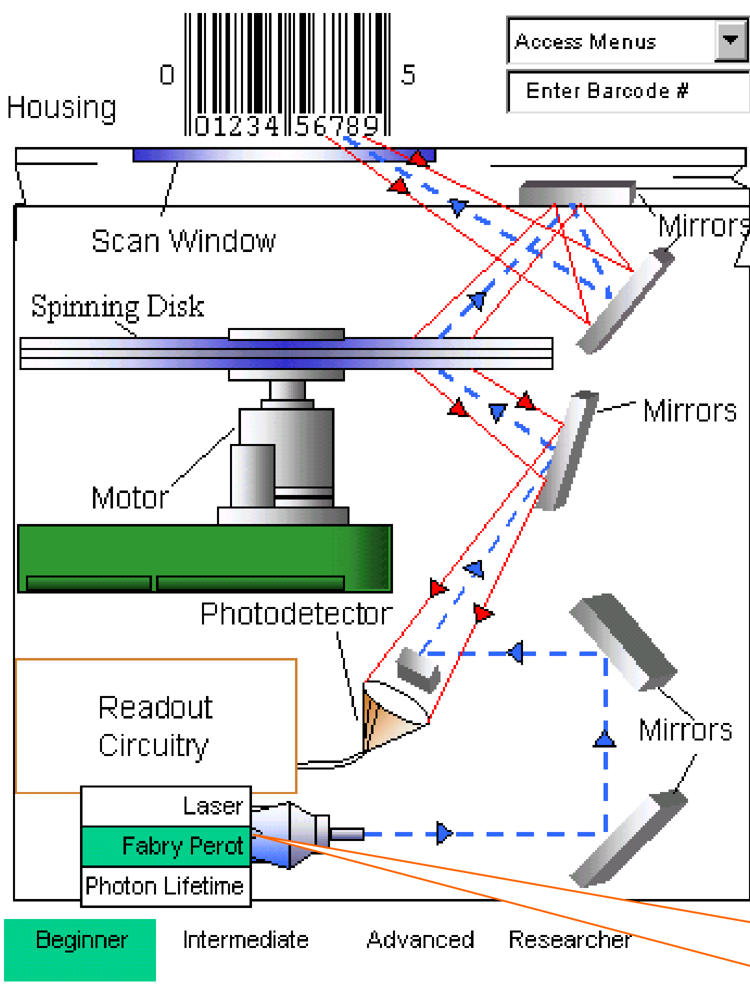
Context Modules

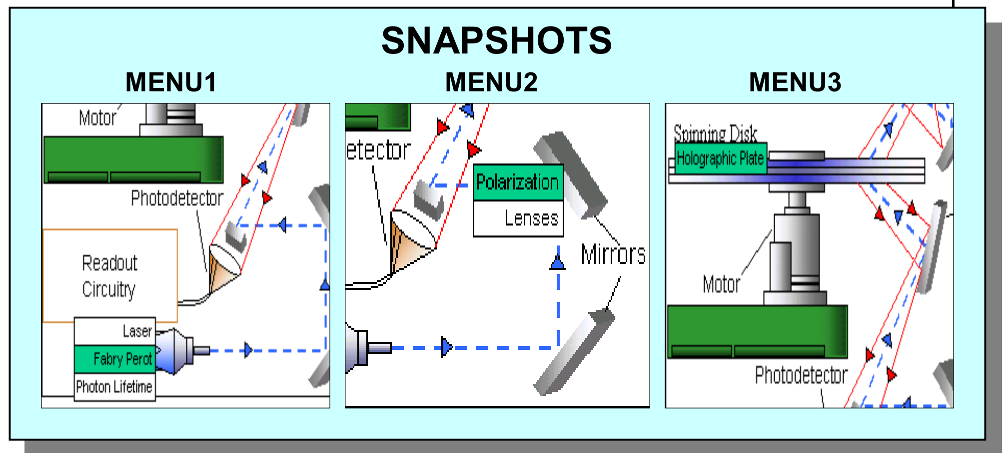
A hierarchical structure of the top level applet for the Barcode Scanner showing all the components Applets



Barcode Scanner – Menu Mode

Barcode Scanner

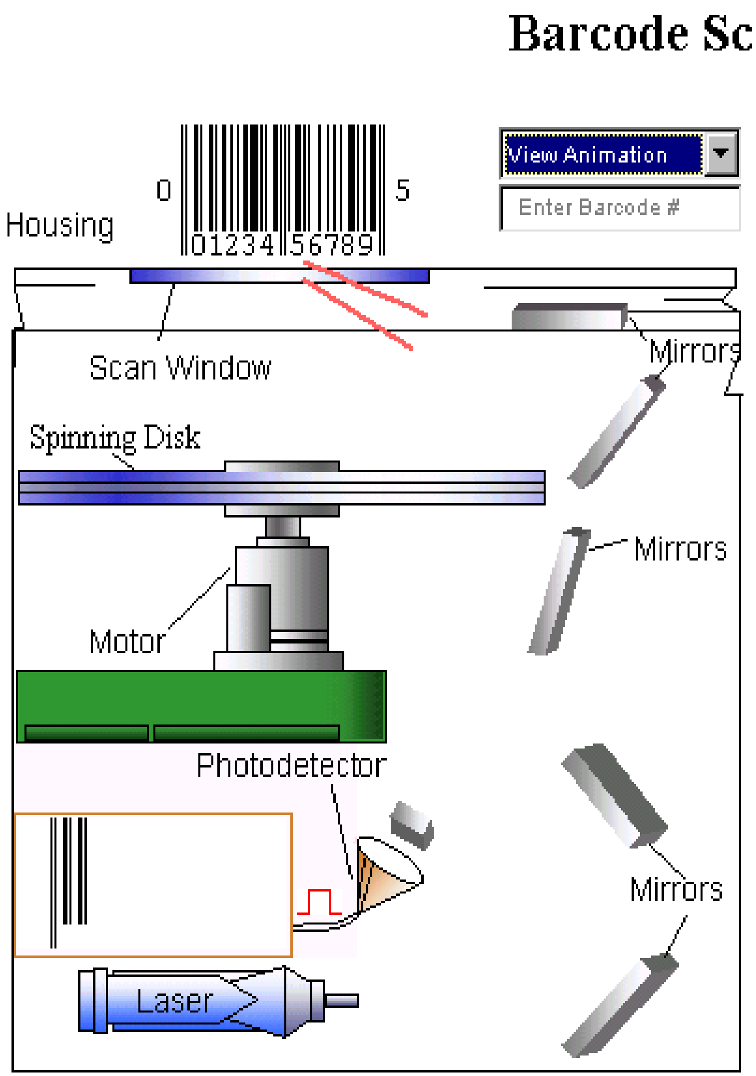


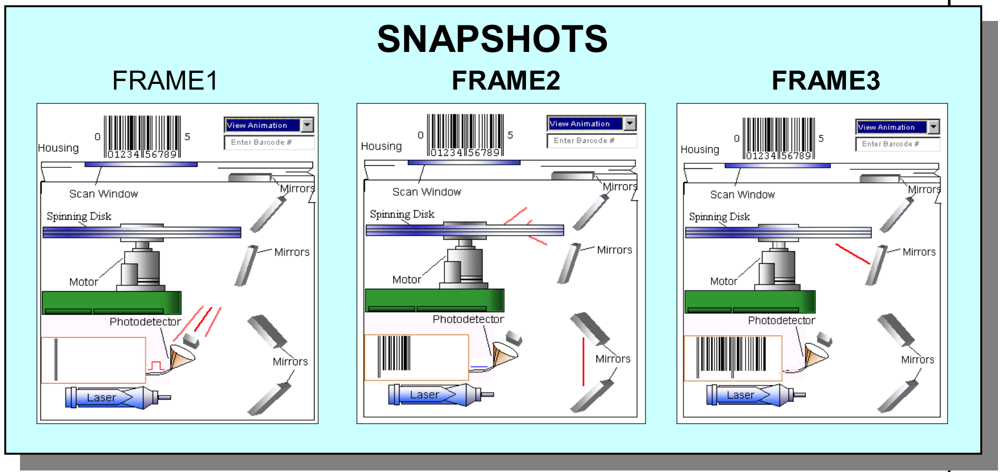


- QuickNote
- Introduction and Tutorial
- References
- Feedback

Selecting topics using menu

Barcode Scanner – Animation Mode





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Applet Design and Development

- General guidelines

  For an applet to provide for virtual experimentation the

  – Applet should be focused on a specific topic
    - educational content should be accurate

  – Applet should portray a good visual representation of concepts
    - Optical Systems require real-world coordinates
      – All objects must be specified with real numbers
      – Allow learners to Zoom
      – Implemented “RealWorld” Objects with this functionality

Applet Design and Development

- General guidelines (cont..)
  - Applet should provide good user interactions
    - Full range of user interactivity (input $\leftrightarrow$ output)
    - Support high speed interactivity
      - avoid heavyweight components
      - Use fast computational algorithms
    - User interaction should be intuitive
      - Give directions for easy operation to avoid frustration
      - Implemented “Balloon Help” in Applet

User Control of Applet Content

Applet content can be modified

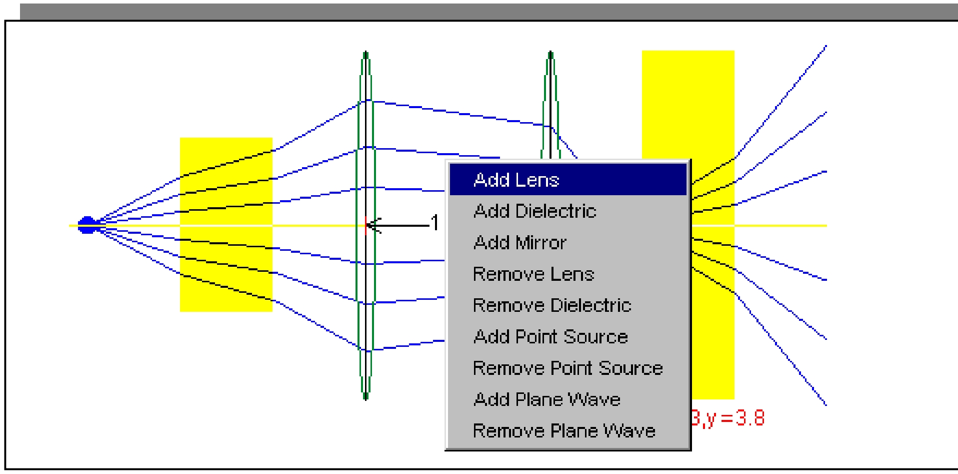
- By Parameter Parsing from HTML

```
<APPLET CODE="ArbMultiLensSys.class" WIDTH=500 HEIGHT=350>

      <PARAM NAME=separator VALUE=",">
      <param name=Lens0 value="10,0,20">
      <param name=Lens1 value="5,10,20">
      <param name=Dielectric0 value="2,-10,10,5">
      <param name=Dielectric1 value="2,15,20,5">
      <param name=PointSource0 value="-15,0,30,60,7,5">
      <param name=PlaneWave0 value="-20,0,10,20">

</APPLET>
```

- By Menu Options at run time



User Control of Applet Content

Content control facilitates

- Rapid development of new applets without additional development work
- Virtual simulation of any experimental setup at run time

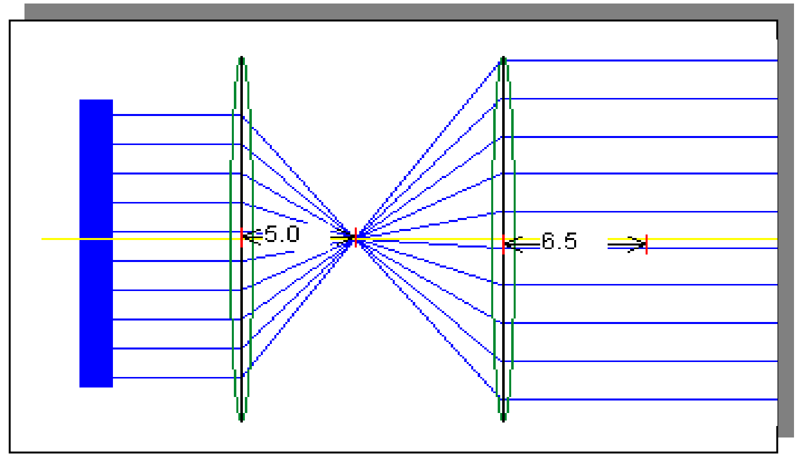
Example

Beam Expander

```
<APPLET CODE="ArbMultiLensSys.class" WIDTH=500 HEIGHT=350>

    <PARAM NAME=separator VALUE=",">
    <param name=Lens0 value="5.0,-9.5,20">
    <param name=Lens1 value="6.5,2.2,20">
    <param name=PlaneWave0 value="-20,0,10,20">

</APPLET>
```



Ray Tracing For Optical Components

Paraxial Ray Tracing Using ABCD Matrices

- The ABCD Matrix completely characterizes a optical component.
- The ABCD Matrix is represented as :

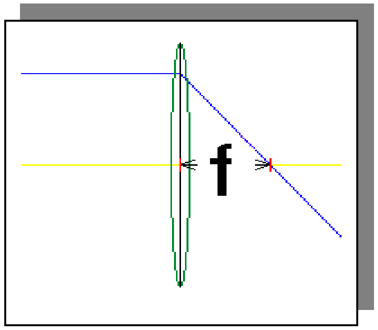
$$\begin{bmatrix} y_o \\ \theta_o \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} y_{in} \\ \theta_{in} \end{bmatrix}$$

y is the y coordinate of the ray

θ is the angle of the ray

- ABCD Matrix for

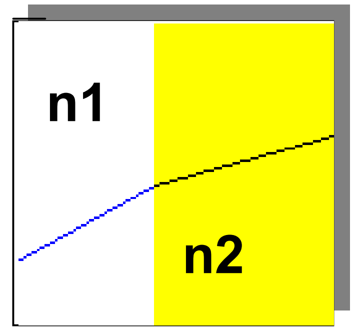
Lens is $\begin{bmatrix} 1 & 0 \\ 1/f & 1 \end{bmatrix}$



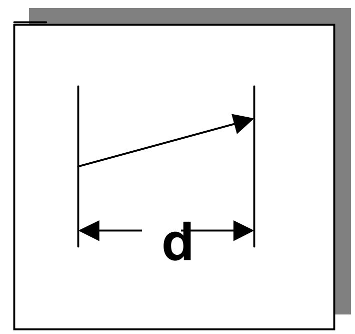
Ray Tracing For Optical Components

– ABCD Matrix for

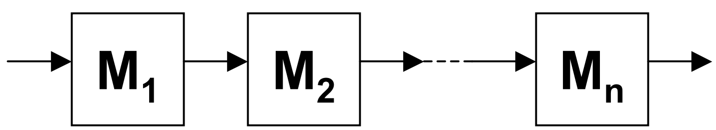
Planar Boundary is $\begin{bmatrix} 1 & 0 \\ 0 & n1/n2 \end{bmatrix}$



Free Space is $\begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix}$

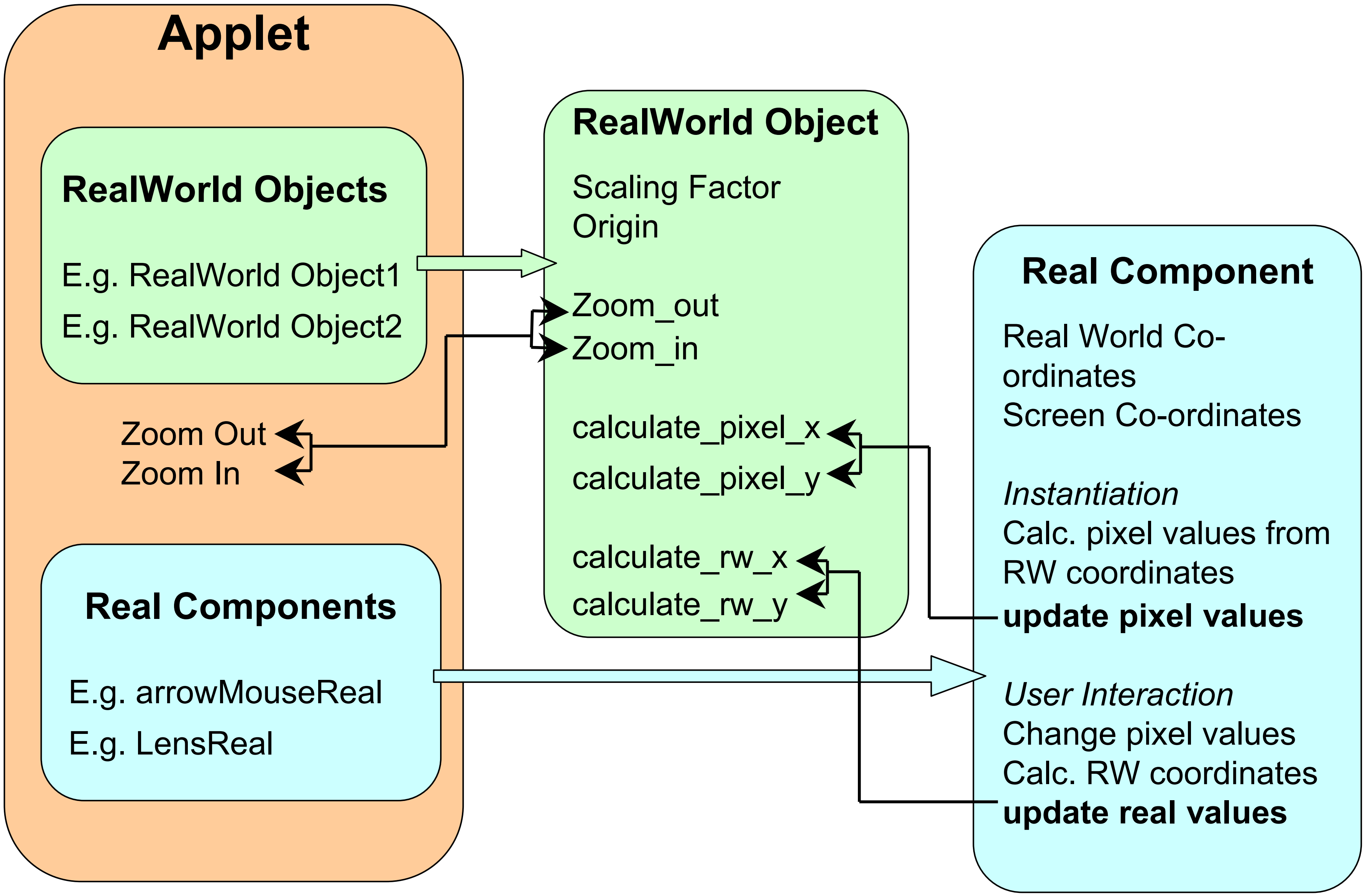


Equivalent Matrix of Cascaded Optical Components



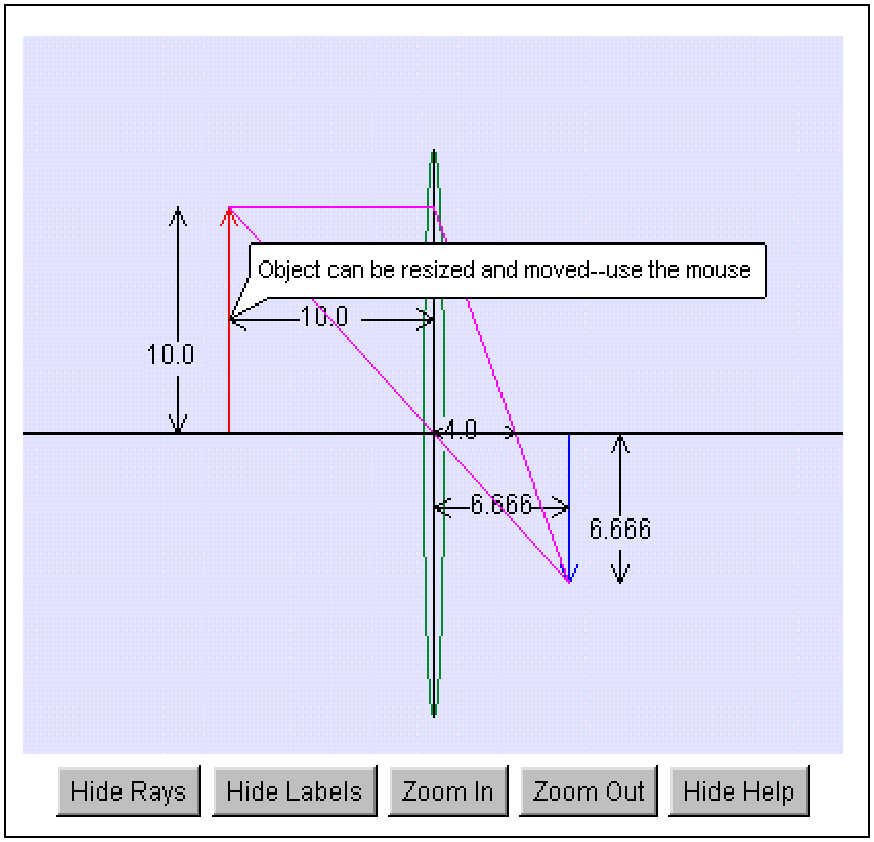
$M = M_n \ldots M_2 M_3$

Implementing “RealWorld” Interface

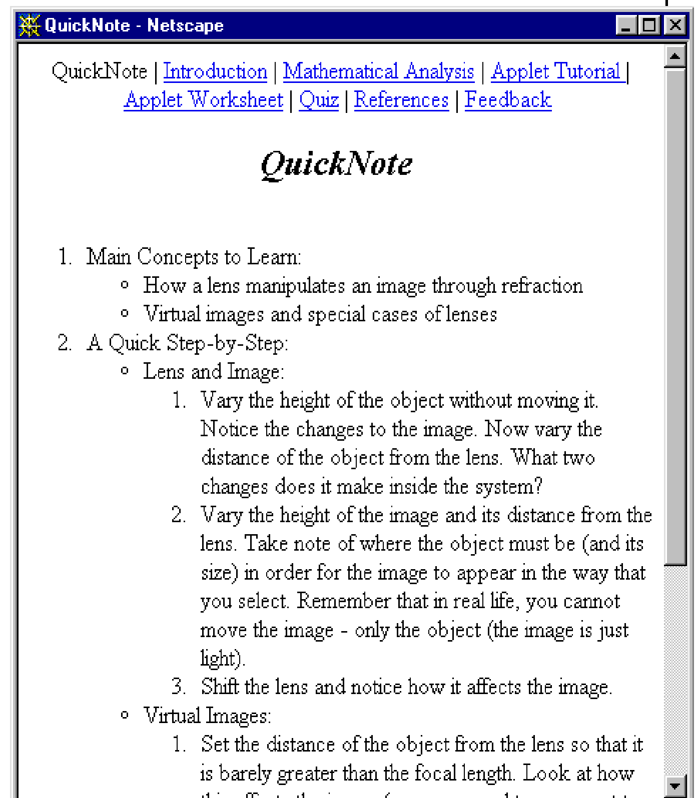


Barcode Scanner – Beginner

Single Lens Optical System



- QuickNote
- Introduction
- Math Analysis
- App.Tutorial
- Worksheet
- Quiz
- SPICE/CAD
- References
- Feedback


QuickNote - Netscape

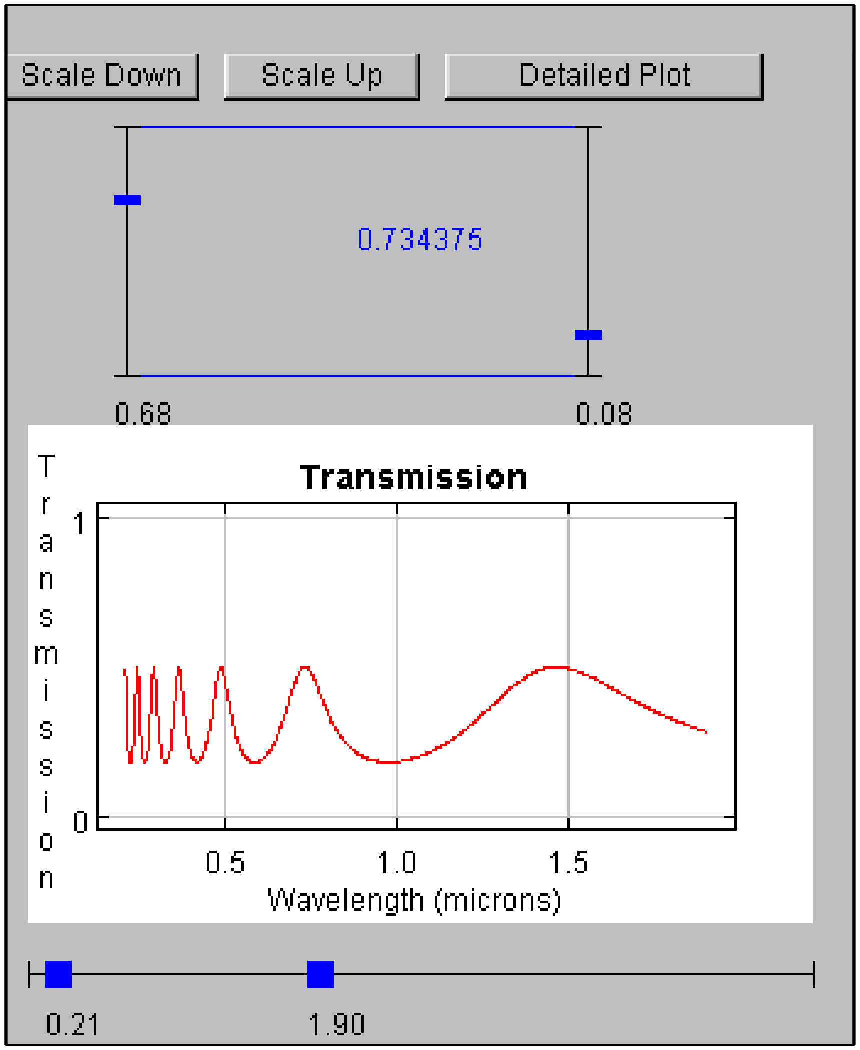
QuickNote | Introduction | Mathematical Analysis | Applet Tutorial | Applet Worksheet | Quiz | References | Feedback

QuickNote

1. Main Concepts to Learn:
   - How a lens manipulates an image through refraction
   - Virtual images and special cases of lenses
2. A Quick Step-by-Step:
   - Lens and Image:
     1. Vary the height of the object without moving it. Notice the changes to the image. Now vary the distance of the object from the lens. What two changes does it make inside the system?
     2. Vary the height of the image and its distance from the lens. Take note of where the object must be (and its size) in order for the image to appear in the way that you select. Remember that in real life, you cannot move the image - only the object (the image is just light).
     3. Shift the lens and notice how it affects the image.
   - Virtual Images:
     1. Set the distance of the object from the lens so that it is barely greater than the focal length. Look at how

Barcode Scanner – Intermediate

The Fabry-Perot Etalon



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Introduction - Netscape

QuickNote | Introduction | Mathematical Analysis | Applet Tutorial | Applet Worksheet | Quiz | References | Feedback

Introduction

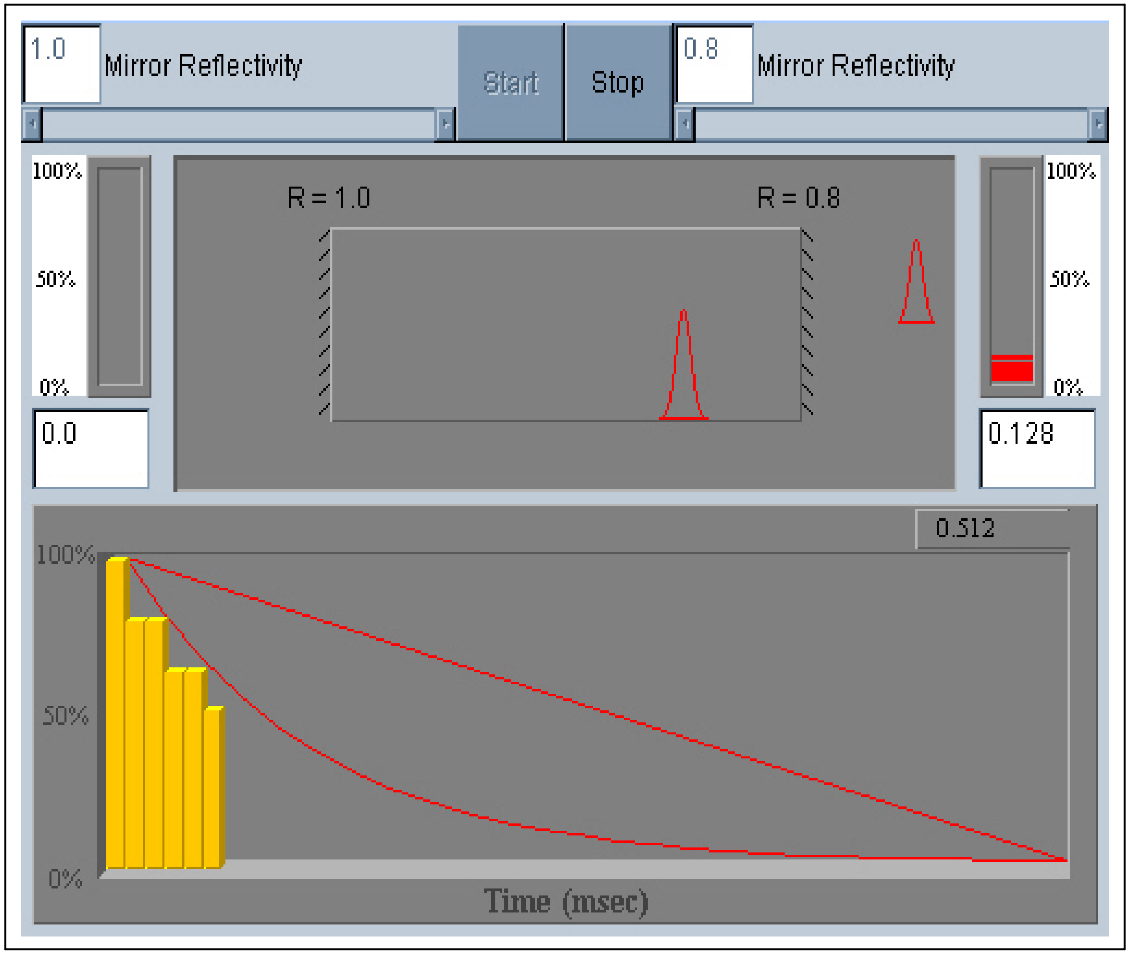
For holograms and other laser applications, the average coherance length of a laser determines the accuracy and quality of the application. Since the coherance length is inversely proportional to the average frequency bandwidth (v), a small bandwidth ensures a long coherance length. Narrowing, the bandwidth, therefore, is a great concern. If the laser is running on a single longitudinal mode that is drifting in frequency during exposure, then v is the total bandwidth covered by drifting mode. An etalon consists of two plane parallel reflective surfaces. An etalon transmits a comb of frequencies gapped by the free spectral range. If an etalon is placed inside a laser, the laser will lase on the one longitudinal mode where a laser longitudinal mode and a etalon mode overlap.

The ideal **Fabry-Perot** etalon consists of an ideal plane-parallel plate of glass thickness L and of index $n(glass)$ immersed in a background of air at index $n(air)$. When an optical beam strikes the first plate, the beam is partially reflected and partially internally transmitted. The transmitted part of the beam then refracts and, after hitting the second plate, partially internally reflects and partially transmits. The internal portion of the beam continues reflecting and transmitting.

In this applet we are concerned with the transmission coefficient. The

Barcode Scanner – Advanced

Photon Lifetime Simulation Applet



- QuickNote
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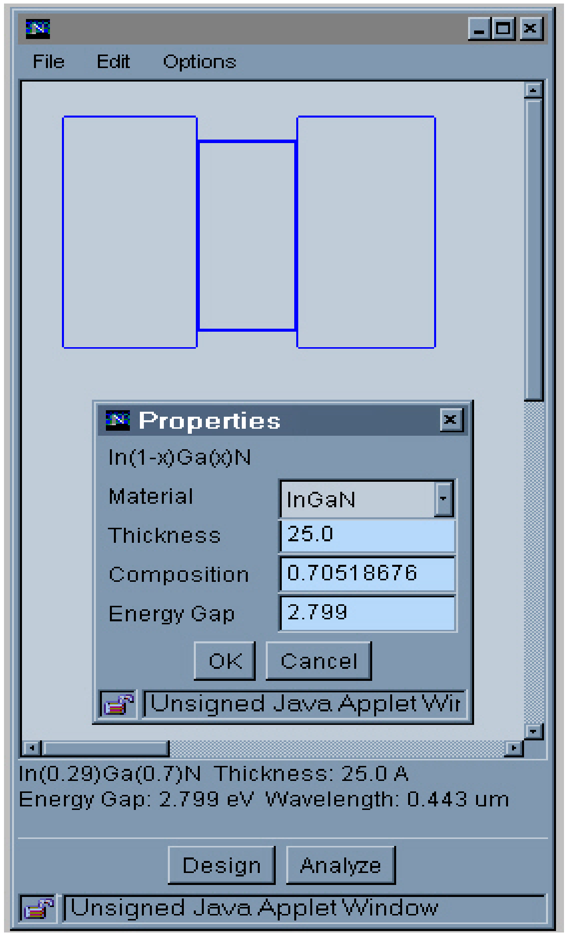
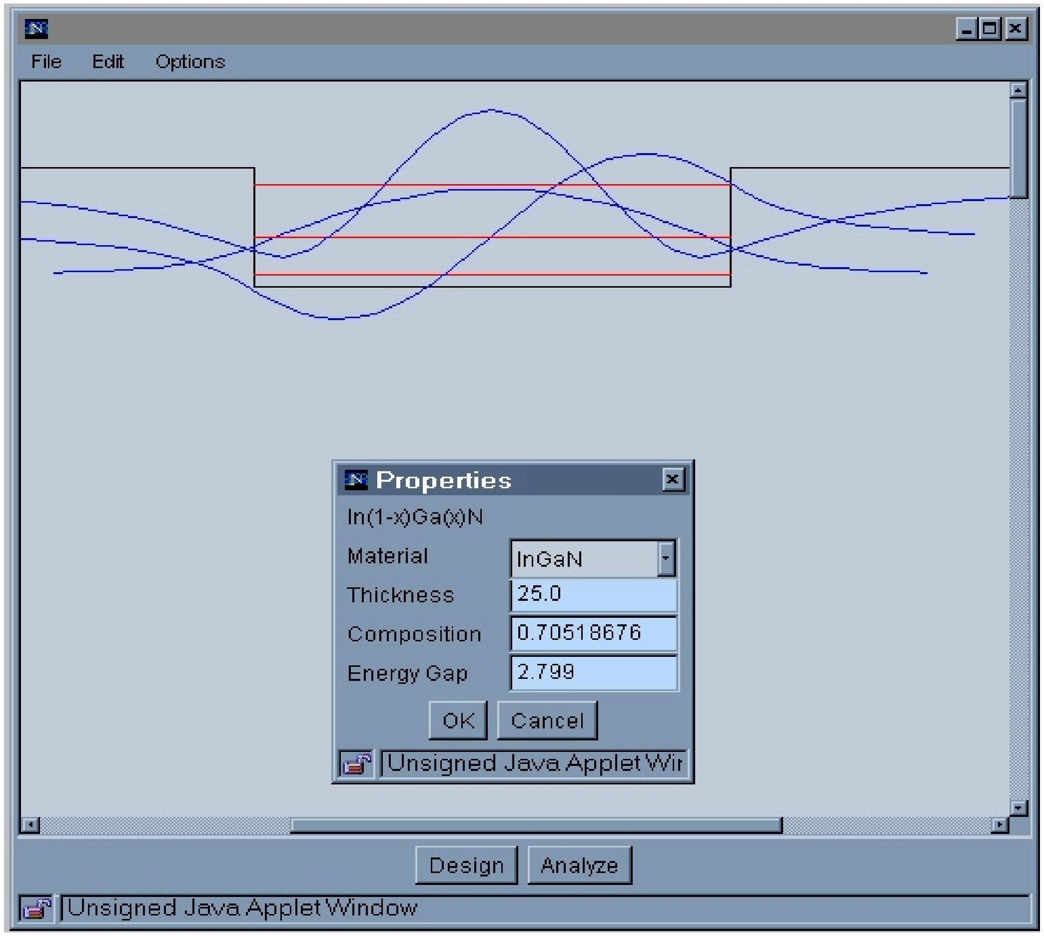
Barcode Scanner – Expert / Research

Design of Quantum Well Materials



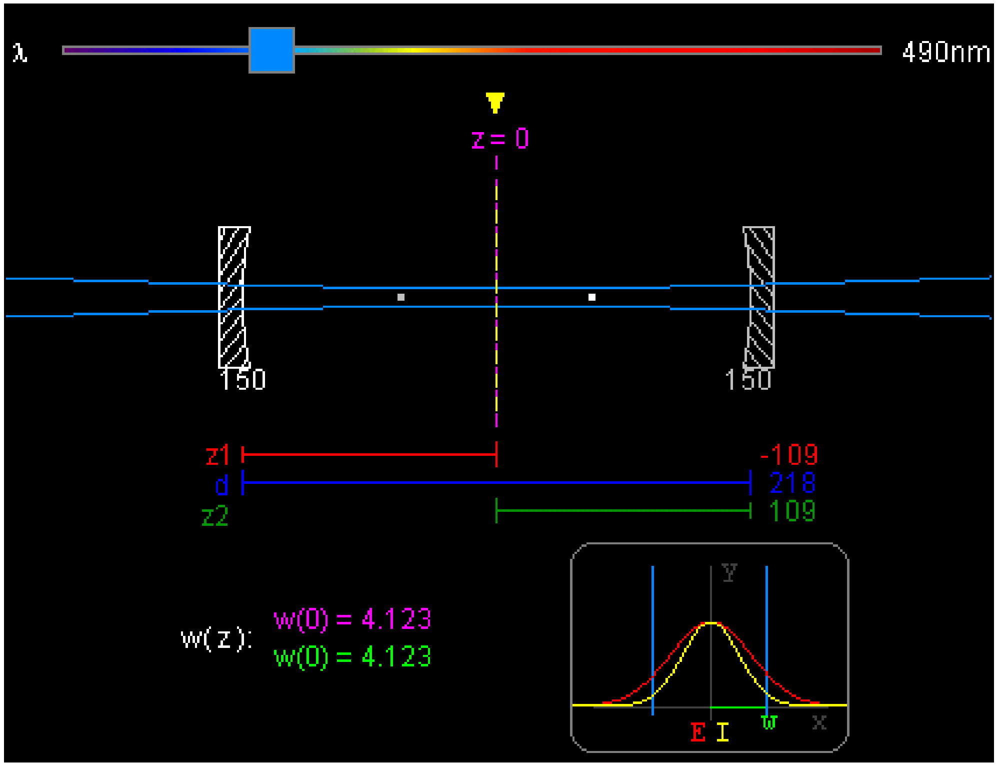
Design Window



Calculated Wavefunctions and Energies

Example Applet

Cavity Stability Applet



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Examples of Future Applets

- Properties of Light
  - Switching of Light
    - Phase modulation
    - Polarization rotation
    - Amplitude modulation
  - Interference
- Photodetectors
  - Wavelength sensitivity
  - Responsivity
  - Speed (Bandwidth)
- Lasers
  - Gain mechanisms – Einstein's A & B Coefficients
  - Gaussian Beam propagation
  - Resonant Cavities

Assessment and Evaluation

- "I think it was technical enough because the simple diagrams speak a thousands words and they help you to see what is really happening. It is difficult to understand what is happening by just reading a textbook."
- "Usability is excelent. The diagram is straight forward. The bar code description is excelent. The photon lifetime discussion may be over a highschool level. The concept of a photon is probably new to them."
- "This is an interesting applet. The system of links is evidently still under construction. The overall idea seems good to me though. A brief, very general description of how the system components work together as a whole might be a nice addition. *You probably know this, but the applet freezes when upper level undergraduate, graduate, or research is selected.*"

Further/Future Assessment

- Paid Reviewers
  - College Professors and Teachers will use in their classes
  - provide an honorarium for evaluating materials
- Honor Students
  - students paid to evaluate content and Applets
  - feedback from these students immediately incorporated
- Classes at SUNY at Buffalo
  - Junior Level:
    - Semiconductor Physics (EE310), Applied Electromagnetics (EE324), Physical Electronics (EE350)
  - Senior Level:
    - Lasers and Photonics (EE492), Consumer Optoelectronics (EE494)
  - Graduate Level:
    - Optical Communication (EE566)

Conclusions

- Applet and website design must be performed concurrently
- Demonstrated:
  - Generic design scheme
  - Specific implementation example
  - Example applets used within the scheme
  - Example design issues for the applets
- Consumer Electronics provides excellent context modules for microelectronics and photonics

References and Acknowledgements

- Center for Active Learning of Microelectronics and Photonics
  - **http://www.ee.buffalo.edu/~camp**
- Microelectronics Java Resource
  - **http://jas2.eng.buffalo.edu/**
- National Science Foundation, Directorate for Education and Human Resources, Division of Undergraduate Education NSF Grant #9950794
  - **http://www.nsf.gov/**
- Center for Advanced Photonic and Electronic Materials
  - **http://www.acsu.buffalo.edu/~capem**