

Mathematica Users Meeting 2005, Prague, September 14, 2005

Mathematica CalcCenter 3

A Small and Useful ICS / CAS
A Versatile Tool for Education
Exact Sciences

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Czech Technical University in Prague

Revised Version

Mathematica CalcCenter 3 : A Versatile Tool for Teaching Exact Sciences

**Integrated Computing Systems
and Teaching Exact Sciences**

References :
Selected live URLs

**Mathematica CalcCenter 3
in Education Exact Sciences**

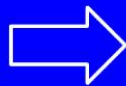


**CalcCenter 3 and Courseware
Development for Exact Sciences**

**Some Mathematica applications
will be also included**

Demonstration :
Learning Express Set

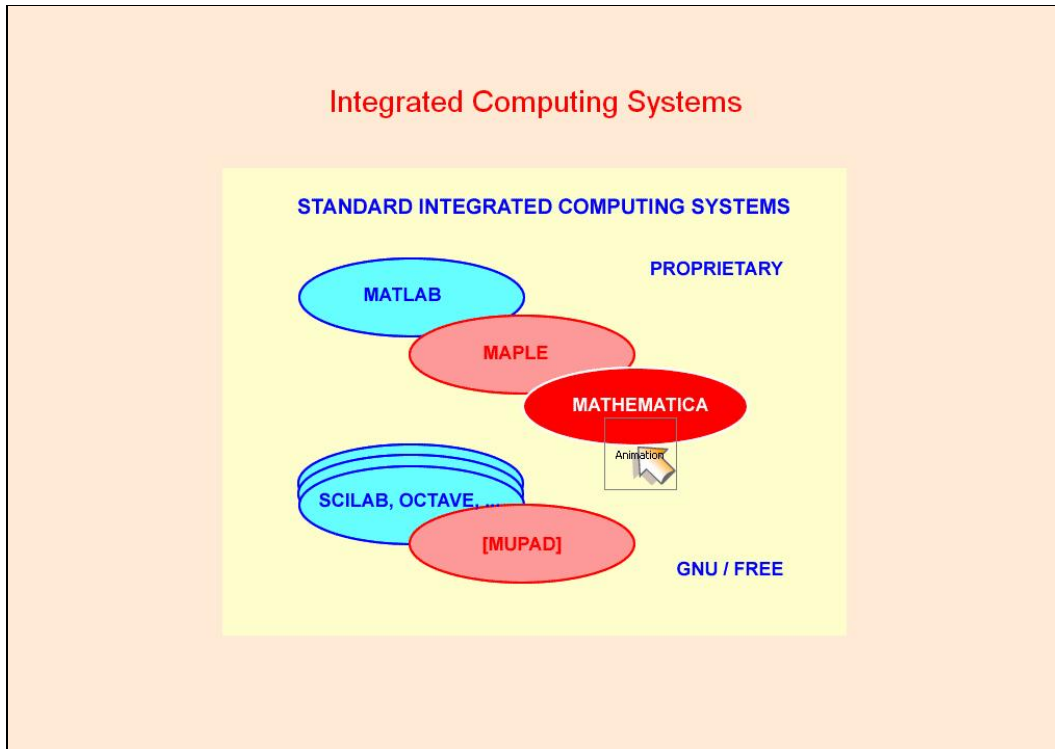
Mathematica CalcCenter 3 : A Versatile Tool for Teaching Exact Sciences

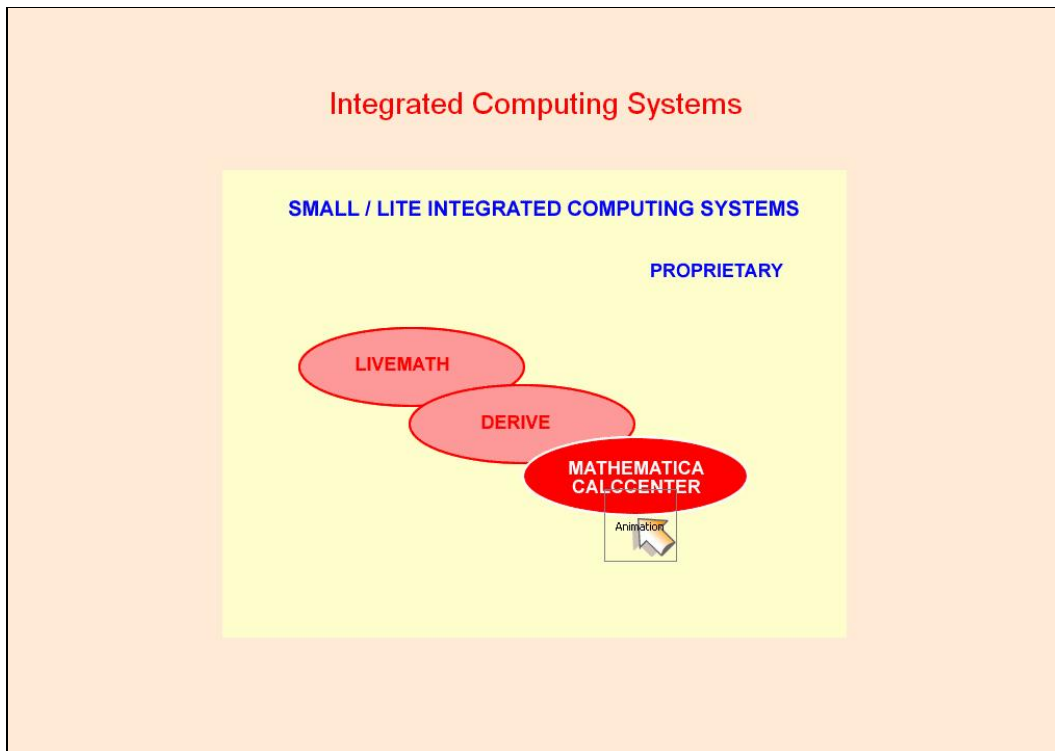


ICS and Teaching Exact Sciences



Integrated Computing Systems





Integrated Computing Systems

SMALL / LITE INTEGRATED COMPUTING SYSTEMS

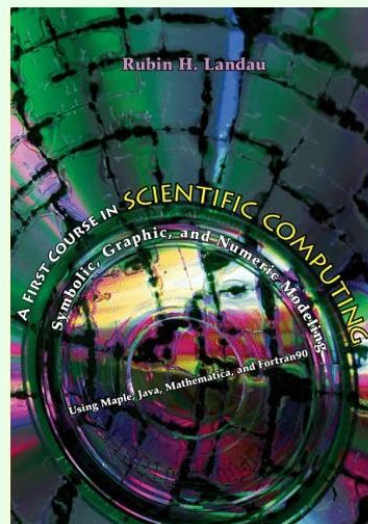
Wolfram Research Inc.

Mathematica
CalcCenter 3

Mathematica Courseware for Physics



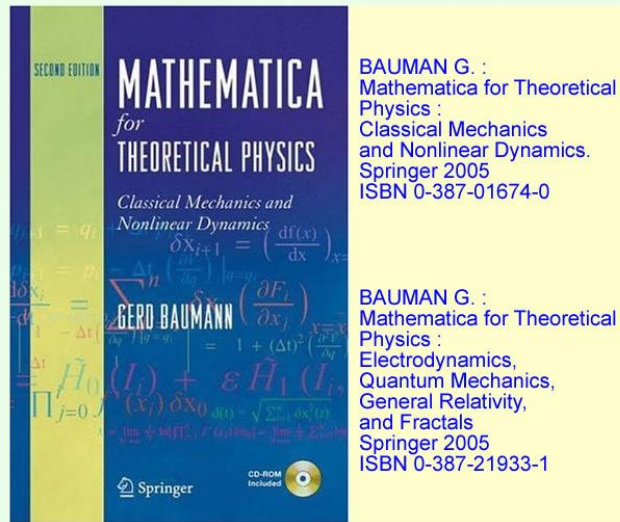
Mathematica Courseware for Physics



LANDAU R.H. :
*A First Course
in Scientific Computing.*
Princeton University
Press 2005
ISBN 0-691-12183-4

DUBIN D. :
Numerical and Analytical
Methods for Scientists
and Engineers,
Using Mathematica.
Wiley 2003
ISBN 0-471-26610-8

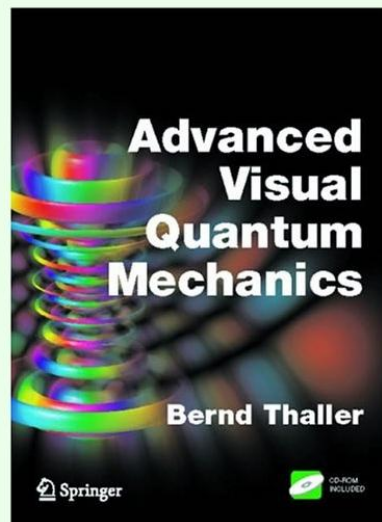
Mathematica Courseware for Physics



BAUMAN G. :
Mathematica for Theoretical
Physics :
Classical Mechanics
and Nonlinear Dynamics.
Springer 2005
ISBN 0-387-01674-0

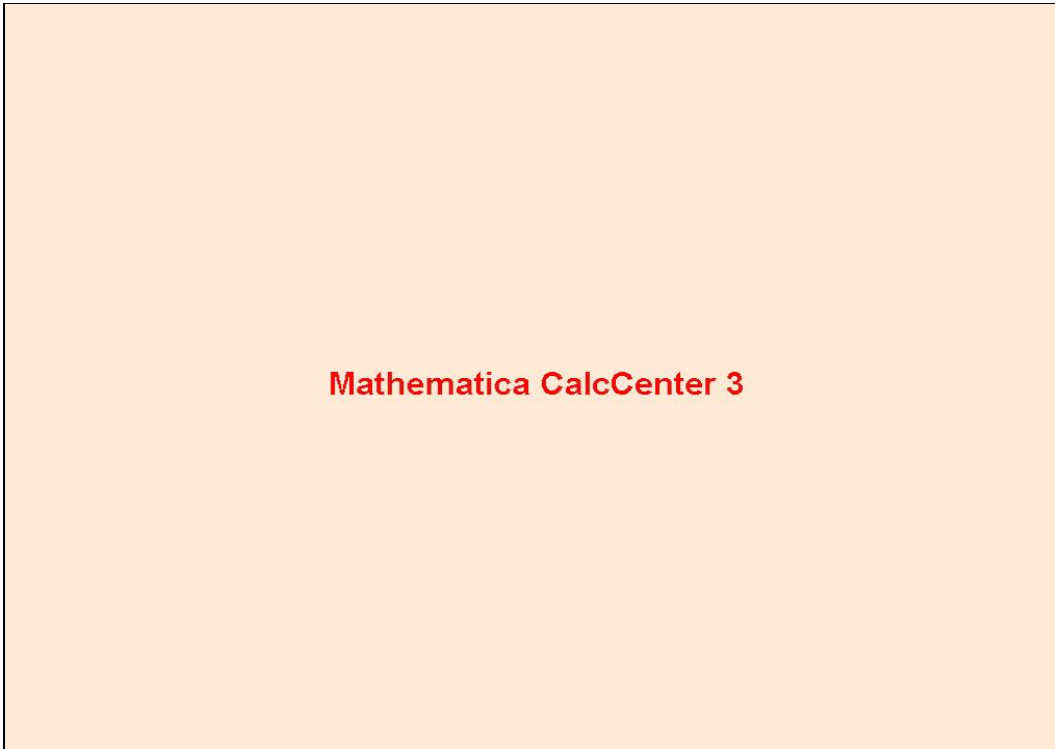
BAUMAN G. :
Mathematica for Theoretical
Physics :
Electrodynamics,
Quantum Mechanics,
General Relativity,
and Fractals
Springer 2005
ISBN 0-387-21933-1

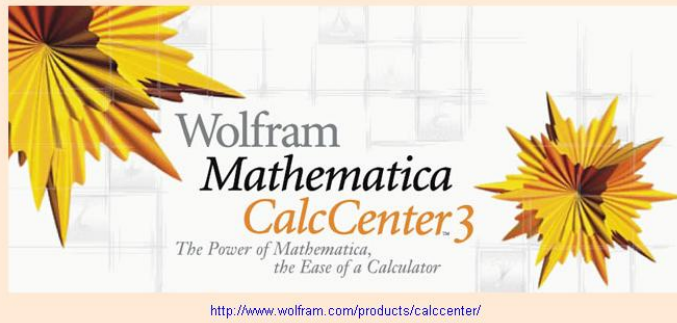
Mathematica Courseware for Physics



THALLER B. :
*Visual Quantum
Mechanics.*
Springer 2000
ISBN 0-387-98929-3

THALLER B. :
*Advanced Visual
Quantum Mechanics.*
Springer 2000
ISBN 0-387-20777-5





Mathematica Calccenter 3

PRODUCT FEATURES

Basic Mathematics

Arithmetic, logarithmic, and exponential functions • Trigonometric and hyperbolic functions • Complex numbers • Bessel functions • Error functions • Numbers • Combinatorial functions

Algebra

Manipulation of expressions • Trigonometric-Exponential conversion • Expression simplification

Calculus

Numeric and symbolic integration and differentiation • Summations and products • Power series expansions

Matrix and Data Operations

Data operations • Import/Export of data • Standard matrix types • Regression • Data manipulation tools • Interpolation • Fast Fourier transform (FFT) • Eigenvectors and eigenvalues • Frequency counting

Statistics

Discrete distributions • Continuous distributions • Probability density functions • Random numbers

Graphics

Plots • Log plots • Contour plots • 3D plots • Scatter plots • Bar charts • Pie charts • Density plots • Polar plots • Inequality plots

Solvers

Algebraic, linear, and differential equation solving • Root finding • Minimum finding

User Definitions

Custom definitions • Loops • Conditionals • Function libraries

Units and Constants

Conversion between any composite units • Conversion to SI or fundamental units

Interface and Help Features

SmartPlot • Help Browser • InstantCalculators • Function controllers • Definition notes • Automatic input correction

Document Features

Text styles • Style sheets • Traditional mathematics input and output • Locked regions • Animations • Typesetting • Special characters

<http://media.wolfram.com/brochures/calcenterspecsheet.pdf>

To continue click FORWARD

Mathematica CalcCenter 3

GENERAL FEATURES

Numeric and symbolic computation and matrix handling

Menu and button interface

Uses *Mathematica's* record-breaking numerical math libraries for fast and accurate results

Comes with over 500 function templates in plain English, which you can fill in and evaluate straightaway

SmartPlot gives you the best visualization for your function or data automatically

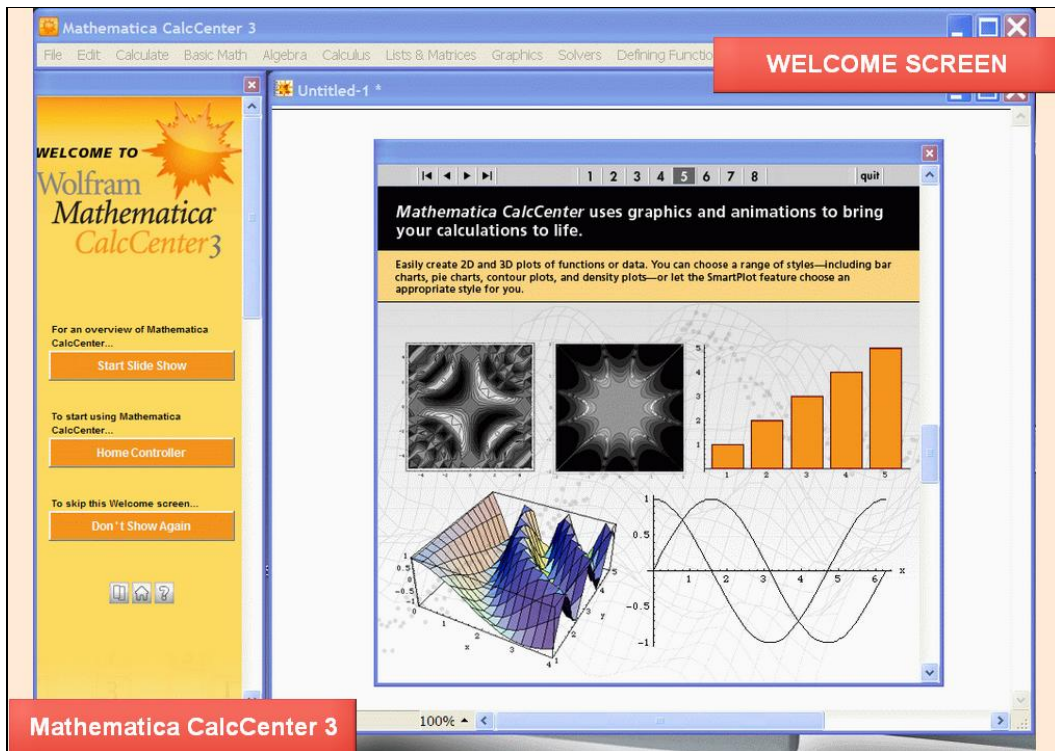
Automatic input correction—if *Mathematica CalcCenter* does not understand proposed input, it will suggest an alternative

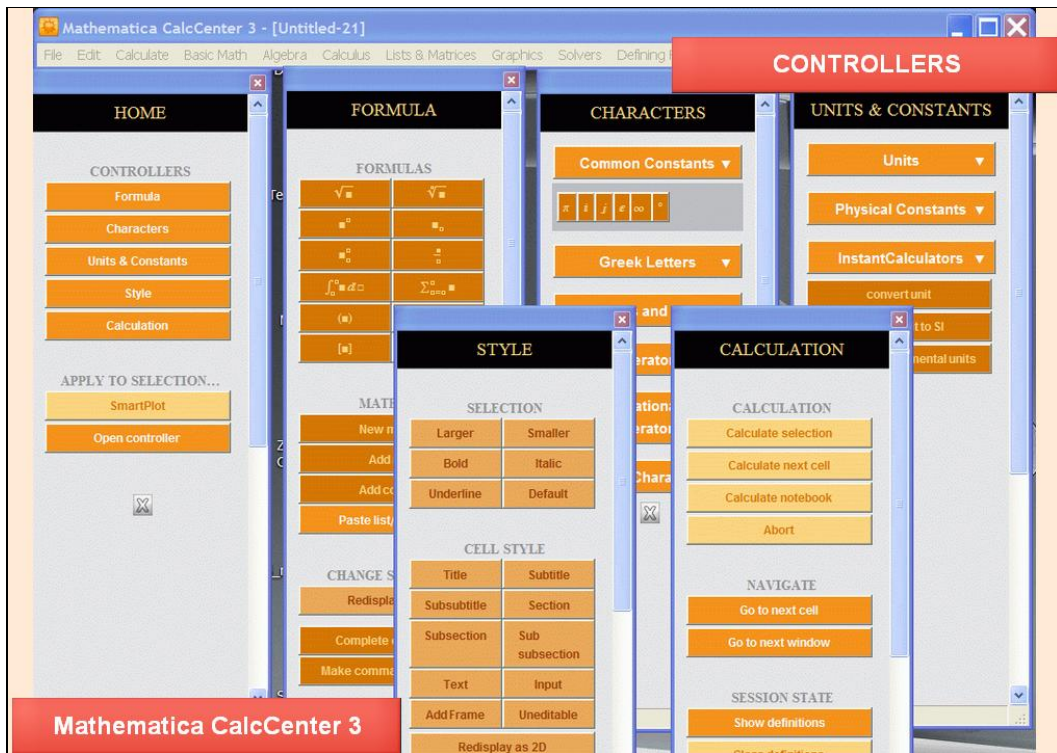
Mathematica notebook interface lets you document your work as you go, including typesetting, graphics, ...

Built-in spell checker

<http://media.wolfram.com/brochures/calccenterspecsheet.pdf>

To continue click FORWARD





The screenshot displays the Mathematica CalcCenter 3 interface. The main window is titled "Mathematica CalcCenter 3 - [mcc3_11.nb]". A red "TEMPLATES" button is visible in the top right corner. The left sidebar contains a navigation menu with sections: "NIntegrate", "INSTANTCALCULATORS" (with buttons for "numerically integrate over range", "numerically integrate up to ∞ ", and "numerically integrate from $-\infty$ to ∞ "), "TEXT INPUT" (with buttons for "NIntegrate[...]" and "NIntegrate[(last answer)]"), and "HELP" (with buttons for "Definition Note" and "Full Help").

The main workspace shows three "CALCULATION TEMPLATES" for the NIntegrate function:

- Template 1:** "numerically integrate up to ∞ ". It includes fields for "The function to integrate", "With respect to the variable", and "The variable's lower bound". A "Calculate" button is present. A red callout box on the right says "Template : numerically integrate up to infinity".
- Template 2:** "numerically integrate up to ∞ ". The input field contains $\frac{1}{1+x^2}$, the variable is x , and the lower bound is 0 . The output is `Out[1]= 1.570796327`. A red callout box on the right says "Show example & Calculate".
- Template 3:** "numerically integrate up to ∞ ". The input field contains $x^3 / (\text{Exp}[x] - 1)$, the variable is x , and the lower bound is 0 . The output is `Out[2]= 6.493939402`. A red callout box on the right says "Integrate from 0 to inf : $x^3 / (\text{Exp}[x] - 1)$ ". Below the output, a red callout box says "Edit the result".

The bottom status bar shows "Mathematica CalcCenter 3" and a zoom level of "100%".

Mathematica CalcCenter 3

References

Wolfram Research Inc.:
Mathematica CalcCenter 3.
<http://www.wolfram.com/products/calccenter>

Wolfram Research Inc.:
Mathematica CalcCenter 3. Documentation.
<http://documents.wolfram.com/calccenter/>

Wolfram Research Inc.:
Mathematica CalcCenter 3. Features.
<http://www.wolfram.com/products/calccenter/features>

Live URLs are available in REFERENCES

Mathematica CalcCenter 3

Reviews

Hogan D. :

Mathematica CalcCenter 3 (Review).

Bitwise Magazine, August 2005

http://www.bitwisemag.com/copy/reviews/software/maths/calc_center.html

Seiter Ch. :

Mathematica CalcCenter (Review).

Macworld, July 28, 2005

<http://www.macworld.com/2005/07/reviews/calccenter3/index.php>

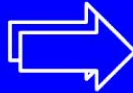
Scientific Solutions :

Wolfram Mathematica CalcCenter 3.

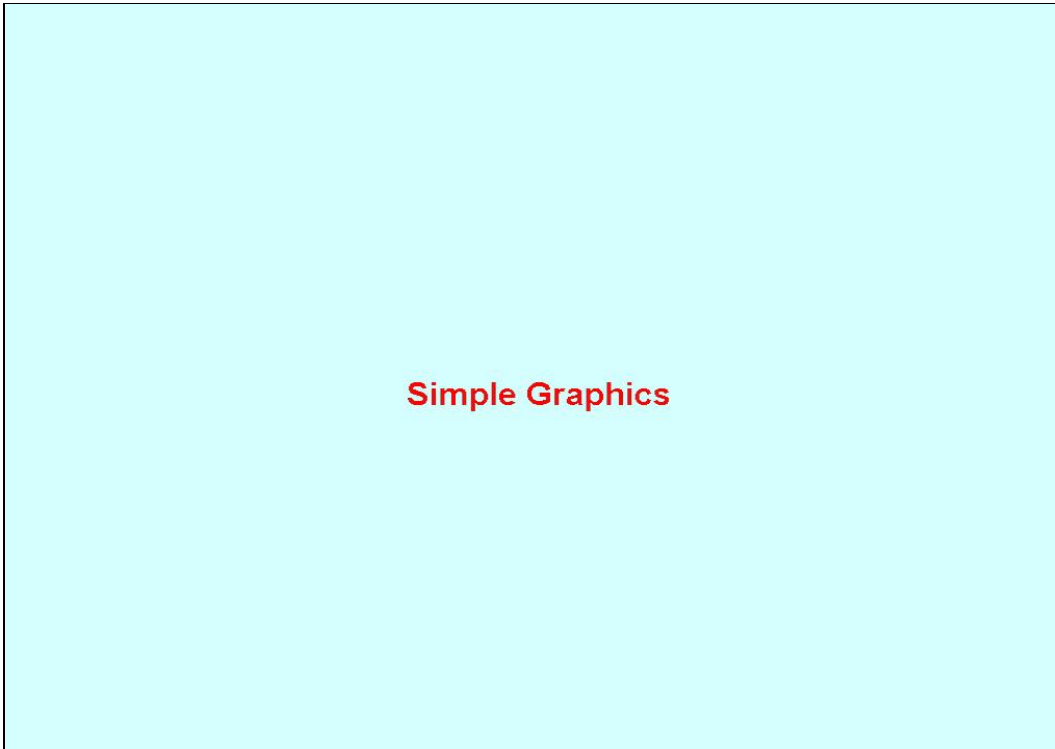
<http://www.scientific-solutions.ch/tech/calccenter/index.html>

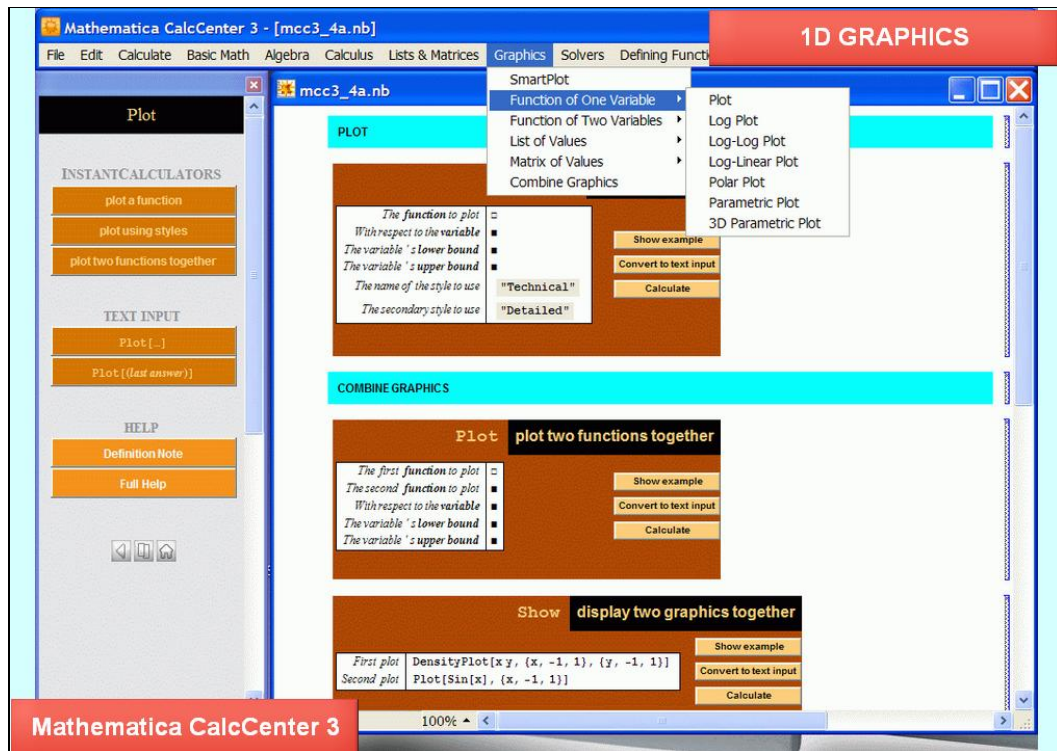
Live URLs are available in REFERENCES

Mathematica CalcCenter 3 : A Versatile Tool for Teaching Exact Sciences



Mathematica CalcCenter 3 in Education ES





Blackbody Radiation

Radiated power per area
per unit wavelength

$$S = \frac{dR}{d\lambda}$$

PLANCK'S LAW

$$S = \frac{A}{\left(\text{Exp}\left(\frac{B}{T\lambda}\right) - 1\right) \lambda^5}$$

WIEN'S LAW

$$S = \frac{A}{\text{Exp}\left(\frac{B}{T\lambda}\right) \lambda^5}$$

RAYLEIGH-JEANS LAW

$$S = \frac{C T}{\lambda^4}$$

$$A = 3.741774873 \times 10^{-16} \text{ [J m}^2\text{]}$$

$$B = 0.0143876866 \text{ [K m]}$$

$$C = 2.600678606 \times 10^{-14} \text{ [J m / K s]}$$

The screenshot displays the Mathematica CalcCenter 3 interface. The title bar reads "Mathematica CalcCenter 3 - [mcc3_19a.nb]". The menu bar includes "File", "Edit", "Calculate", "Basic Math", "Algebra", "Calculus", "Lists & Matrices", "Graphics", "Solvers", and "Defining Functions". A red banner at the top right says "SIMPLE GRAPHICS".

The main window is titled "mcc3_19a.nb" and contains a "PLOT A FUNCTION" section. It defines two functions:

$$\text{Planck}[T, \lambda] := \frac{3.741774873}{10^{16} \left(\frac{0.0143876886}{T\lambda} - 1 \right) \lambda^5}$$
$$\text{RayJeans}[T, \lambda] := \frac{2.600678606 T}{10^{14} \lambda^4}$$

Below the definitions is a "Plot" control panel with a "plot a function" button. A table shows the function to plot as $\text{Planck}[3, \lambda]$, the variable as λ , the lower bound as 0.00002, and the upper bound as 0.003. Buttons for "Show example", "Convert to text input", and "Calculate" are present.

The plot area shows a graph of the Planck function for $T=3$. The x-axis is labeled λ and ranges from 0.0000 to 0.0030. The y-axis ranges from 0.0000 to 0.0030. The curve shows a peak around $\lambda = 0.001$.

At the bottom, there are input fields for the plot command: `Plot[c, {λ, λ}]` and `Plot[c, {λ, λ}, "Default", "None"]`. A red banner at the bottom left says "Mathematica CalcCenter 3".

Mathematica CalcCenter 3 - [mcc3_19b.nb] **SIMPLE GRAPHICS**

File Edit Calculate Basic Math Algebra Calculus Lists & Matrices Graphics Solvers Defining Functions

mcc3_19b.nb

Plot

INSTANTCALCULATORS

- plot a function
- plot using styles
- plot two functions together

TEXT INPUT

- Plot[...]
- Plot[{last answer}]

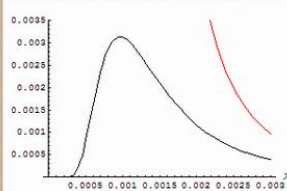
HELP

- Definition Note
- Full Help

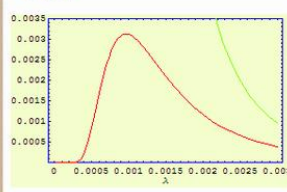
PLOT TWO FUNCTION TOGETHER

```
Plot[{#, #}, {#, #, #}]
```

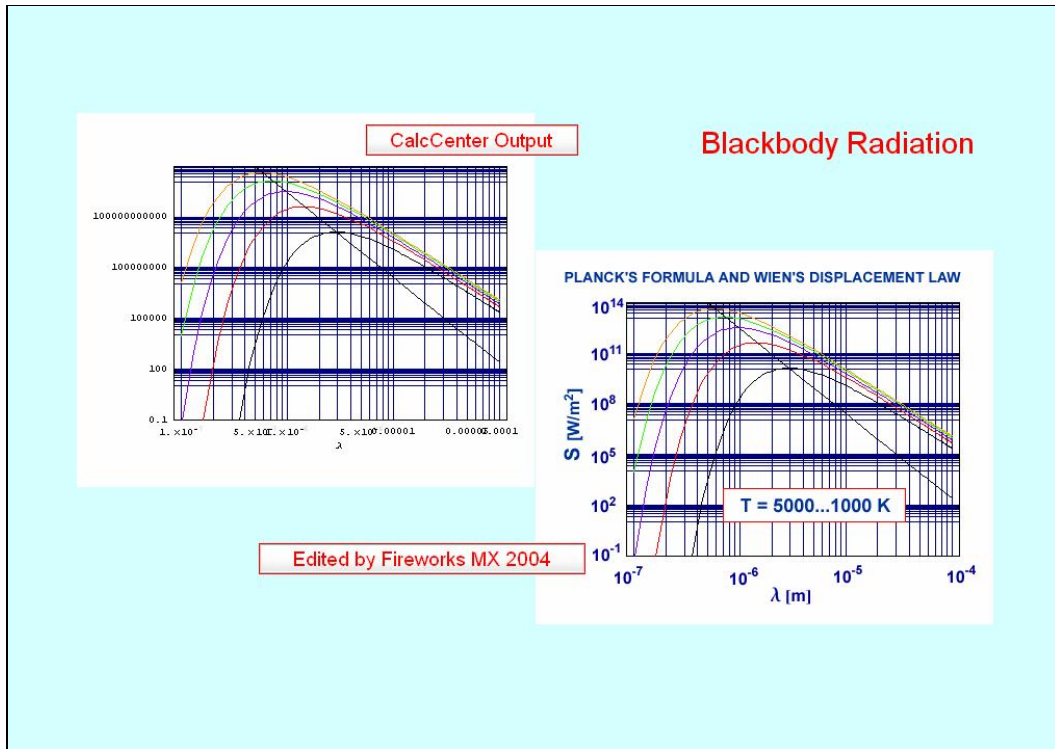
```
Plot[{Planck[3, λ], RayJeans[3, λ]}, {λ, 0.00002, 0.003}, {0, 0.0035}]
```



```
Plot[{Planck[3, λ], RayJeans[3, λ]}, {λ, 0.00002, 0.003}, {0, 0.0035}, "Colorful", "Frame"]
```

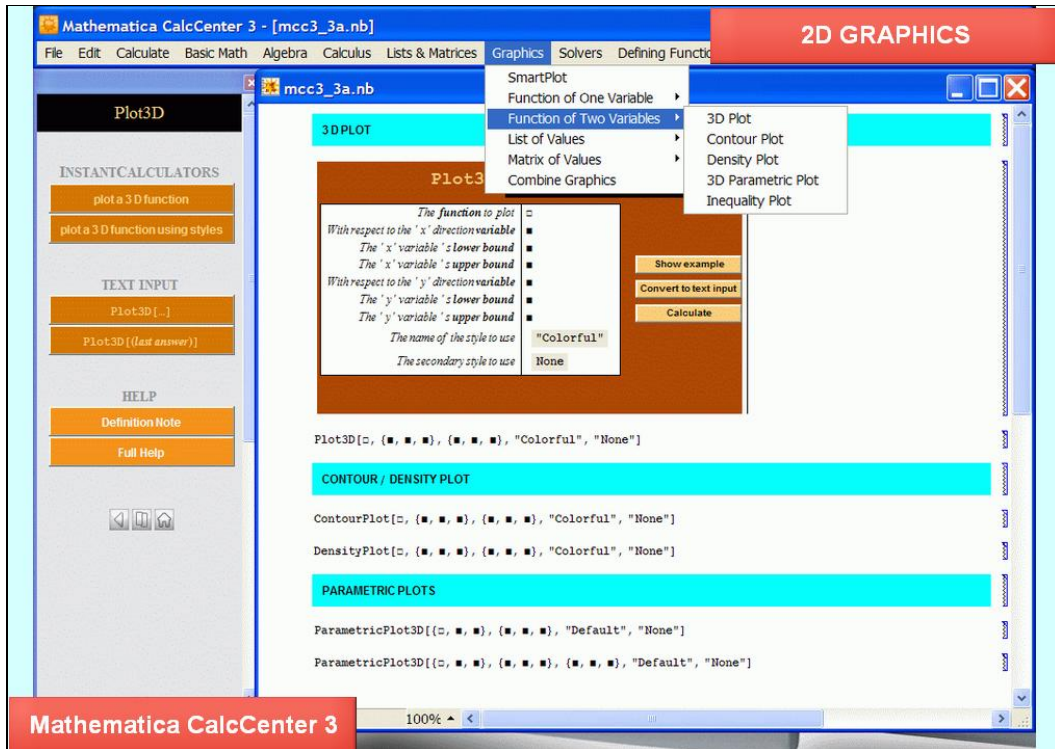


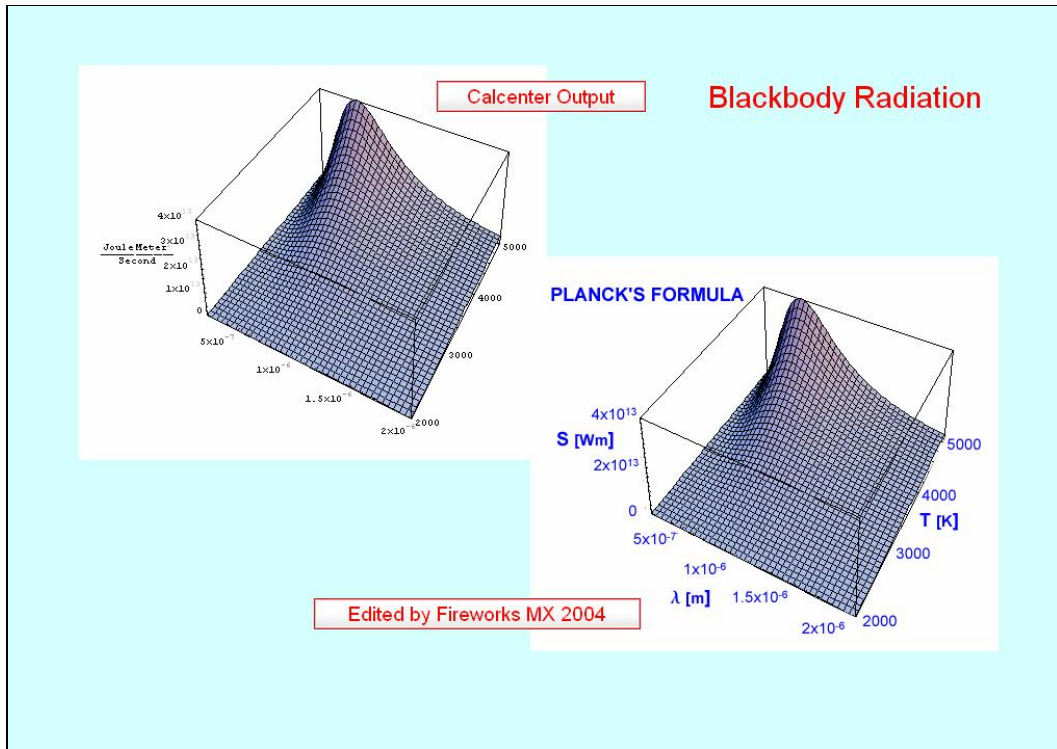
Mathematica CalcCenter 3 100%

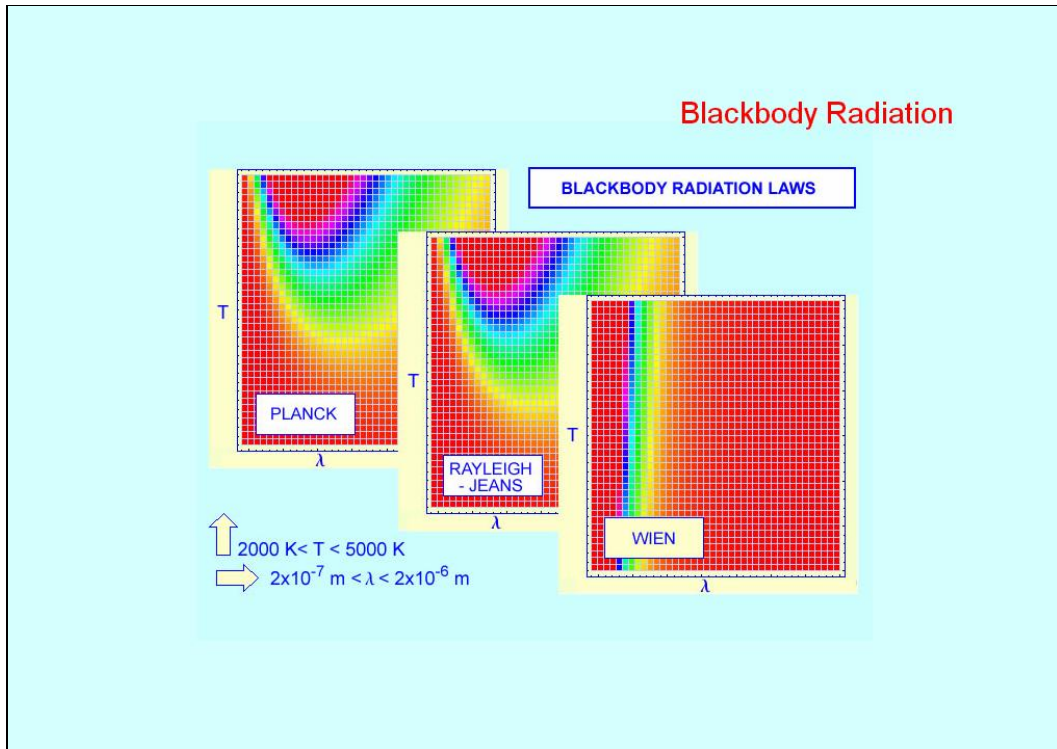




2D Graphics





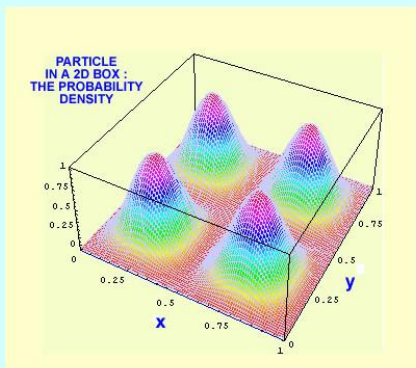


Quantum Wells / Barriers

Particle in a Box

$$U = \infty \quad L = 1$$

$$n_x = 2 \quad n_y = 2$$

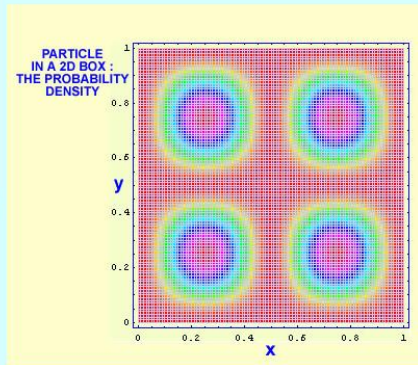


WAVEFUNCTION

$$\psi(x, y) = A \sin \frac{n_x \pi x}{L} \sin \frac{n_y \pi y}{L}$$

PROBABILITY DENSITY

$$\rho(x, y) = |\psi(x, y)|^2$$



Quantum Wells / Barriers

BARRIER TRANSMISSIVITY

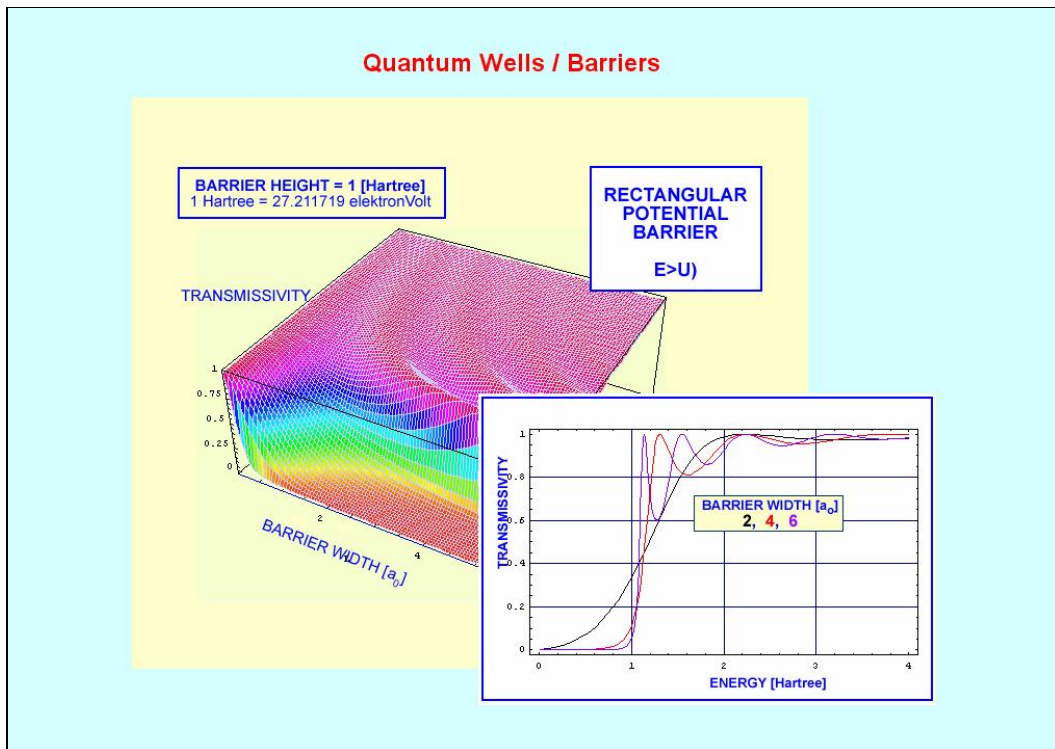
$E > U$

$$T = \frac{4 \frac{E}{U} \left(\frac{E}{U} - 1 \right)}{\sin^2 \left[\frac{\sqrt{2m(E-U)}}{\hbar} L \right] + 4 \frac{E}{U} \left(\frac{E}{U} - 1 \right)}$$

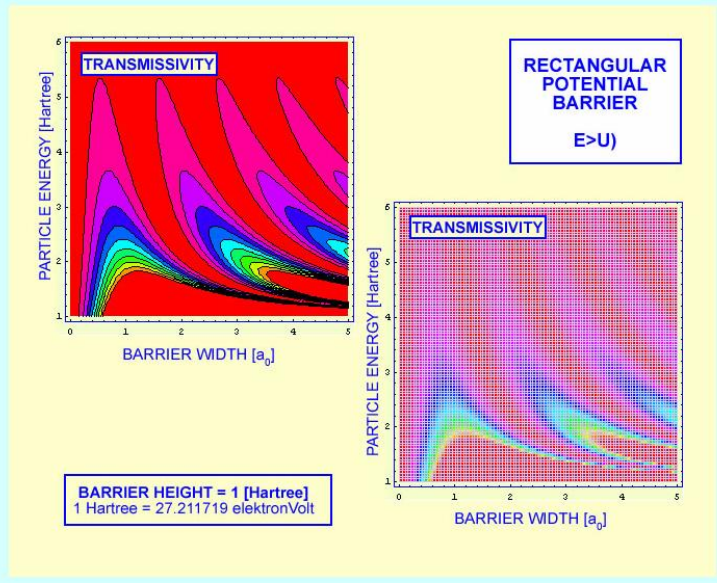
$E > U$
TUNNELING

$$T = \frac{4 \frac{E}{U} \left(1 - \frac{E}{U} \right)}{\sinh^2 \left[\frac{\sqrt{2m(U-E)}}{\hbar} L \right] + 4 \frac{E}{U} \left(1 - \frac{E}{U} \right)}$$

$$m = 1 \quad \hbar = 1$$

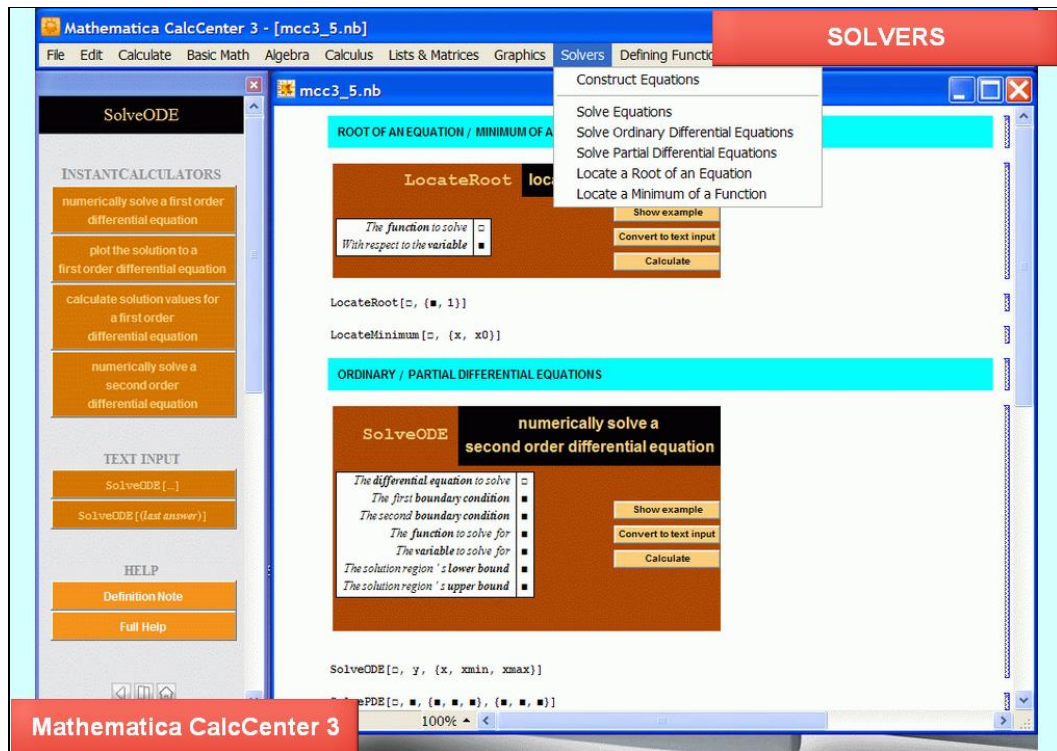


Quantum Wells / Barriers





Equation / ODE Solvers



The screenshot displays the Mathematica CalcCenter 3 interface. At the top, the title bar reads "Mathematica CalcCenter 3 - [mcc3_6.nb]". The menu bar includes "File", "Edit", "Calculate", "Basic Math", "Algebra", "Calculus", "Lists & Matrices", "Graphics", "Solvers", and "Defining Functions". A red "SOLVERS" button is visible in the top right corner.

The main workspace is divided into a sidebar on the left and a central area. The sidebar contains a "SmartPlot" section with "INSTANTCALCULATORS" (visualize a function automatically, visualize data automatically), "TEXT INPUT" (SmartPlot[...], SmartPlot[... (last answer)]), and "HELP" (Definition Note, Full Help). The central area features a "SMART PLOT" dialog box with the following content:

SmartPlot visualize a function automatically

The function to visualize

Plot Visualize $-5(1 - e^{-x}) + x$

x variable

PlotType:
PlotStyle:
SecondaryPlotStyle:

Below the dialog box is a graph of the function $y = x - 5(1 - \exp(-x))$. The x-axis ranges from -1 to 6, and the y-axis ranges from -2 to 2. The curve starts at approximately (-1, -4.5), reaches a minimum near x=2, and then increases, crossing the x-axis at approximately x=5.5.

At the bottom of the window, the status bar shows "Mathematica CalcCenter 3" and "100%".

The screenshot displays the Mathematica CalcCenter 3 interface with three overlapping tool windows:

- SmartPlot (mcc3_6.nb):** Features a "SMART PLOT" header and "visualize a function automatically" button. The input field contains the function $x - 5(1 - \text{Exp}[-x])$. Below, a "Plot" window visualizes the function $-5(1 - e^{-x}) + x$ with an x-axis from -1 to 6. The plot shows a curve that starts at approximately (-1, -5.5) and crosses the x-axis at $x = 0$, reaching a minimum near $x = 2.5$ before rising.
- SolveEquation (mcc3_7.nb):** Features a "SOLVE AN EQUATION" header and "solve an equation" button. The input field contains the equation $x - 5(1 - \text{Exp}[-x]) == 0$ with respect to variable x . The output field shows the solution $x = 4.965114232$.
- SmartPlot (mcc3_7.nb):** A smaller version of the SmartPlot window, partially obscured by the SolveEquation window.

The main interface includes a menu bar (File, Edit, Calculate, Basic Math, Algebra, Calculus, Lists & Matrices, Graphics, Solvers, Defining Functions) and a sidebar with "INSTANTCALCULATORS" and "HELP" sections. A red banner at the bottom left reads "Mathematica CalcCenter 3".

Coulomb Systems

THE HYDROGEN ATOM

COULOMB POTENTIAL

$$U(r) = -\frac{1}{4\pi\epsilon_0} \frac{e^2}{r}$$

FACTORIZED WAVE FUNCTION

$$\psi(r, \vartheta, \phi) = R(r) \Theta(\vartheta) \Phi(\phi)$$

RADIAL EQUATION : R - EQUATION

$$-\frac{\hbar^2}{2m} \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial}{\partial r} \right) R(r) + \left[\frac{\hbar^2 l(l+1)}{2mr^2} - \frac{1}{4\pi\epsilon_0} \frac{e^2}{r} \right] R(r) = ER(r)$$

The screenshot displays the Mathematica CalcCenter 3 interface. The main window is titled "Mathematica CalcCenter 3 - [mcc3_8p.nb]". The top menu bar includes "File", "Edit", "Calculate", "Basic Math", "Algebra", "Calculus", "Lists & Matrices", "Graphics", "Solvers", and "Defining Functions". A red "SOLVERS" button is visible in the top right corner.

The central workspace is titled "ORDINARY DIFFERENTIAL EQUATIONS" and features a "SolveODE" tool. The tool's interface includes a text area with the following text:

SolveODE numerically solve a second order differential equation

The differential equation to solve $x''[\rho] - (\rho^2 - 3) * x[\rho] == 0$
 The first boundary condition $x'[0] == 1$
 The second boundary condition $x[0] == 0$
 The function to solve for $x[\rho]$
 The variable to solve for ρ
 The solution region's lower bound 0
 The solution region's upper bound 4

Buttons for "Show example", "Convert to text input", and "Calculate" are located to the right of the text area.

Below the tool, the output area shows three examples of solving ODEs:

Out[1]= $x[\rho]$
 InterpolatingFunction[{{0 4}}, <>][ρ]

In[2]= `res2 = SolveODE[{x''[\rho] - (\rho^2 - 2.9) x[\rho] == 0, x'[0] == 1, x[0] == 0}, x[\rho], {\rho, 0, 4}]`

Out[2]= $x[\rho]$
 InterpolatingFunction[{{0 4}}, <>][ρ]

In[3]= `res3 = SolveODE[{x''[\rho] - (\rho^2 - 3.1) x[\rho] == 0, x'[0] == 1, x[0] == 0}, x[\rho], {\rho, 0, 4}]`

Out[3]= $x[\rho]$
 InterpolatingFunction[{{0 4}}, <>][ρ]

The bottom of the window shows a red "Mathematica CalcCenter 3" label and a zoom level of "100%".

The screenshot displays the Mathematica CalcCenter 3 interface. The title bar reads "Mathematica CalcCenter 3 - [mcc3_9p.nb]". The menu bar includes "File", "Edit", "Calculate", "Basic Math", "Algebra", "Calculus", "Lists & Matrices", "Graphics", "Solvers", and "Defining Functions". A red "SOLVERS" button is visible in the top right corner. The left sidebar contains a "Plot" section with "INSTANTCALCULATORS" (plot a function, plot using styles, plot two functions together), "TEXT INPUT" (Plot[_], Plot[{(last answer)}]), and "HELP" (Definition Note, Full Help). The main workspace shows the "Graphics" menu open, with "SmartPlot" selected. A sub-menu is open, listing "Function of One Variable", "Function of Two Variables", "List of Values", "Matrix of Values", and "Combine Graphics". A "PLOT OF THE RESULTS" dialog box is open, showing a "Plot" window with the following content:

The function to plot	(res1, res2, res3)
With respect to the variable	ρ
The variable's lower bound	0
The variable's upper bound	4
The name of the style to use	"Technical1"
The secondary style to use	"Frame"

Below the dialog is a plot of a function on a coordinate plane. The x-axis ranges from 0 to 4, and the y-axis ranges from -0.5 to 1. The plot shows a curve that starts at (0,0), rises to a peak of approximately 0.6 at x=1, dips to a minimum of approximately -0.2 at x=2.5, and then rises sharply to approximately 1.0 at x=4. The plot is titled "Plot" and "plot using styles". Buttons for "Show example", "Convert to text input", and "Calculate" are visible.

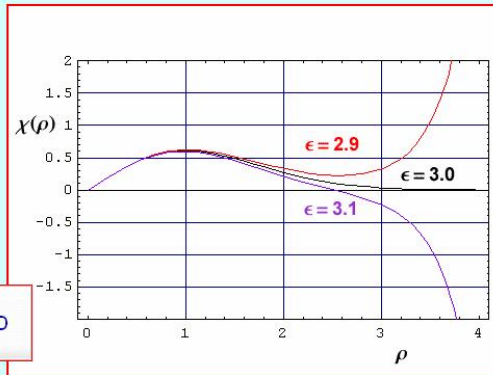
At the bottom of the window, the status bar shows "Mathematica CalcCenter 3" and "100%".

Coulomb Systems

$$X''(\rho) = \left(\rho^2 + \frac{l(l+1)}{\rho^2} - \epsilon \right) X(\rho)$$

REDUCED R-EQUATION

Ground State : n = 1, l = 0



THE HYDROGEN ATOM
SOLUTION OF THE REDUCED
RADIAL EQUATION

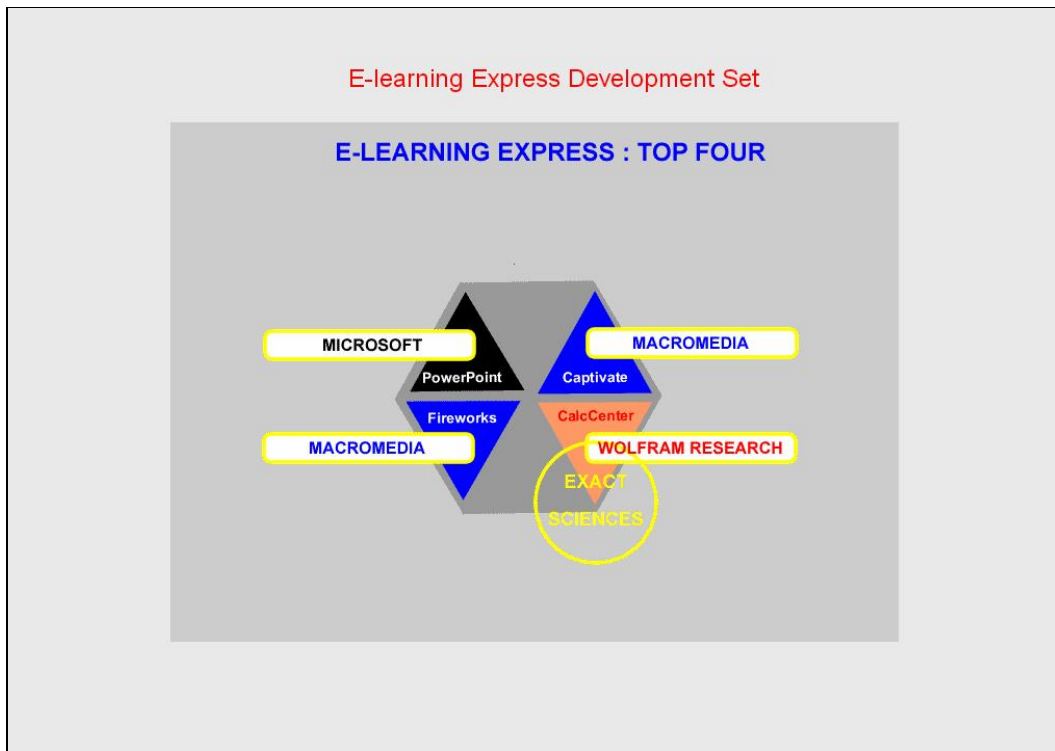
Mathematica CalcCenter 3 : A Versatile Tool for Teaching Exact Sciences

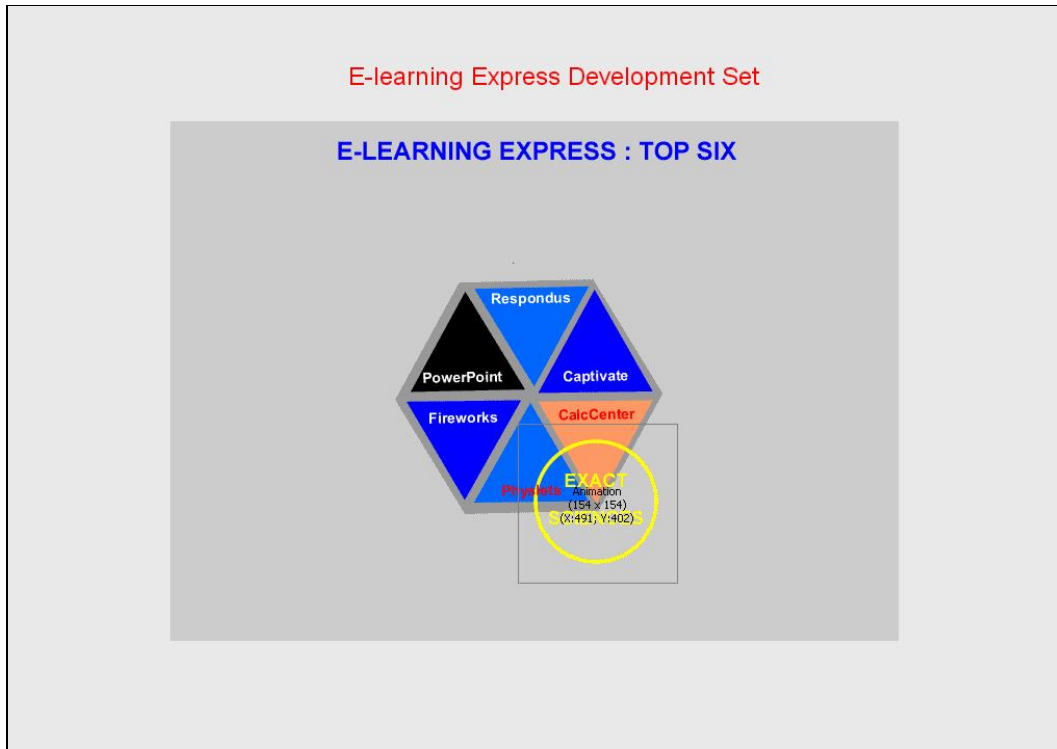


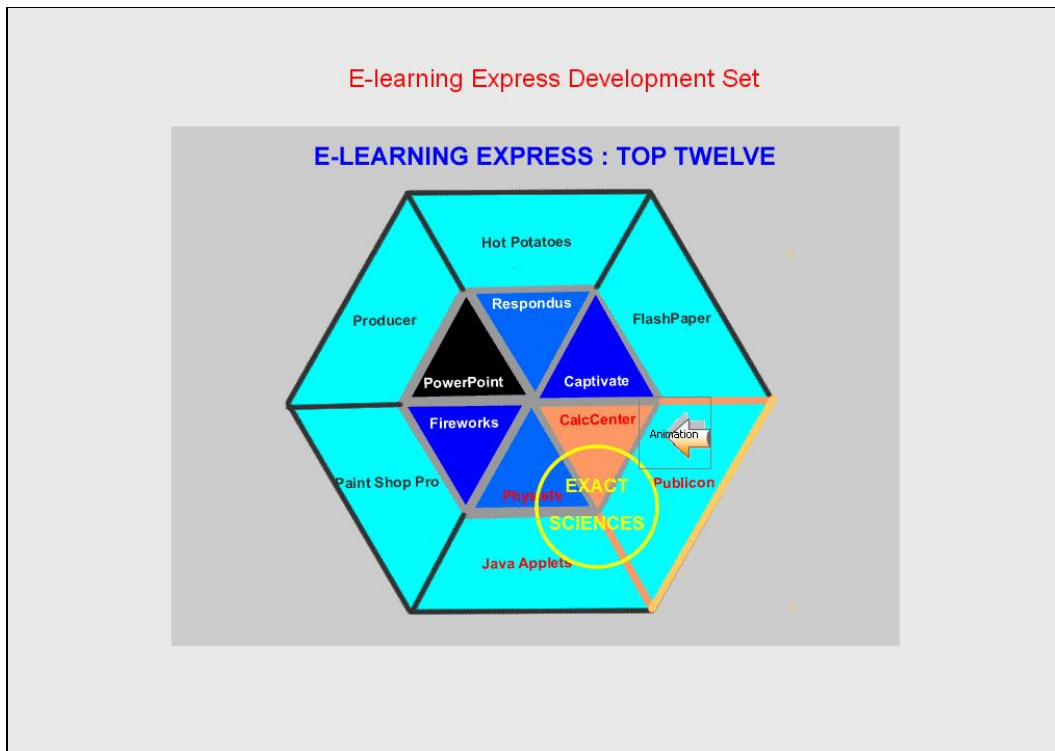
MCC3 and Courseware Development for ES



E-learning Express Development Set







E-learning Express

Drška L. :

*E-Learning Express : Řešení pro pěšáky (a všední dny) /
E-Learning Express : A Solution for Pedestrians (and
Everydays).*

In : Konference EMTECH 2005, Praha, 6.-7. června 2005
<http://vega.fjfi.cvut.cz/docs/emtech05/>

Drška L. :

*E-Learning Express : Řešení pro pěšáky (a všední dny) /
E-Learning Express : A Solution for Pedestrians (and
Everydays).*

Presentation Record.

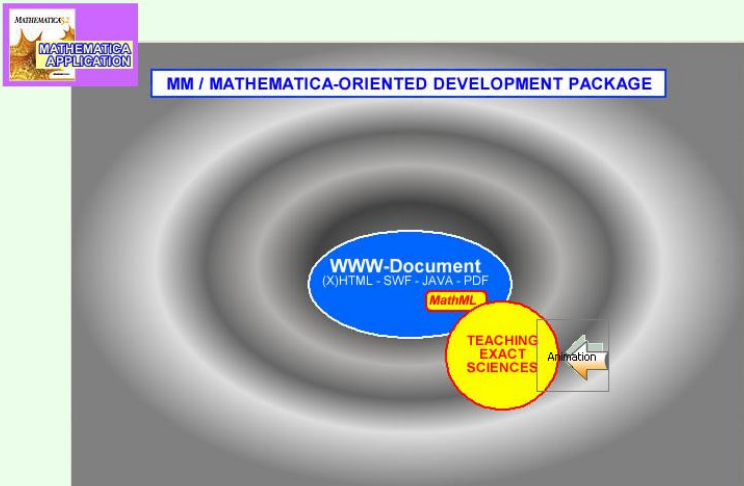
In : Konference EMTECH 2005, Praha, 6.-7. června 2005.
Proceedings (DVD)

Live URLs are available in REFERENCES

Sophisticated Development Set MM / WRI

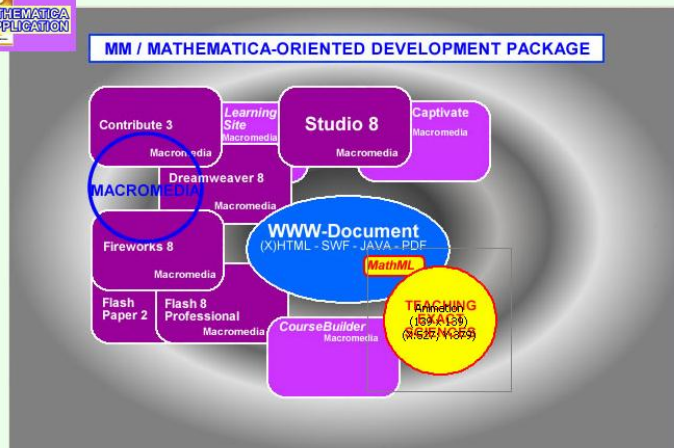


Sophisticated Development Set MM / WRI

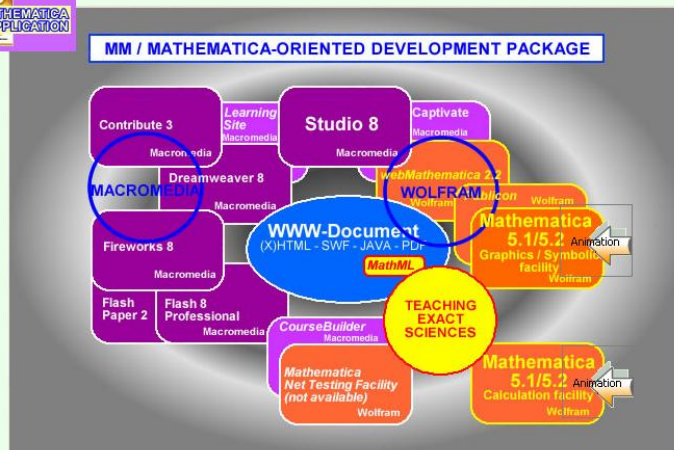


The screenshot displays a Mathematica application window with a light green background. At the top center, the text "Sophisticated Development Set MM / WRI" is written in red. Below this, a dark gray rectangular area contains several elements: a small purple icon labeled "MATHEMATICA APPLICATION" in the top left; a blue-bordered box with the text "MM / MATHEMATICA-ORIENTED DEVELOPMENT PACKAGE"; a central blue oval containing the text "WWW-Document" and "(X)HTML - SWF - JAVA - PDF"; a small red "MathML" label; a yellow circle with the text "TEACHING EXACT SCIENCES"; and a small "Animation" icon with a right-pointing arrow.

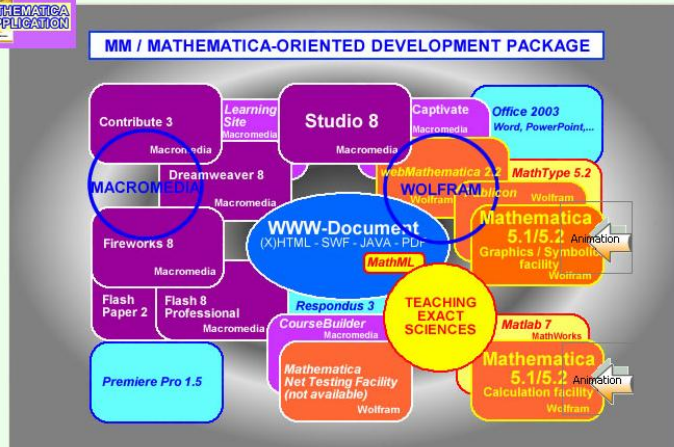
Sophisticated Development Set MM / WRI



Sophisticated Development Set MM / WRI



Sophisticated Development Set MM / WRI



E-learning Express Applications

Cech Technical University
Faculty of Nuclear Sciences and
Physical Engineering
Applied & Engineering Physics.
<http://aep.fjfi.cvut.cz/aep/>

Drška L.:

Fundamentals of Nonclassical Physics :
Introduction.

<http://vega.fjfi.cvut.cz/docs/fncphys/>

Drška L.:

Speciální teorie relativity. Kviz. Část 1. /
The Special Theory of Relativity. Quiz. Pt. 1.

http://vega.fjfi.cvut.cz/docs/emtech05/test_rel1.htm

Live URLs are available in REFERENCES

Courseware Development for Exact Sciences

Drška L. :

*Koncepce a technologie coursewaru pro exaktní obory /
Courseware Concepts and Technology for Exact Sciences.*

In : Konference BELCOM 05, Praha, 21.-22. února 2005.

<http://vega.fifi.cvut.cz/docs/belcom05/>

Drška L. :

Intensive Course Concepts of Postmodern Physics.

In : Workshop CTU 2005, March 2005

<http://vega.fifi.cvut.cz/docs/w2005add/>

Live URLs are available in REFERENCES

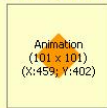
**Mathematica CalcCenter 3 : A Versatile Tool for Teaching Exact
Sciences**



Demonstrations & References

E-learning Express Demo
Selected Live URLs

Please, see the homepage of this document



HOME PAGE

Mathematica CalcCenter 3 : A Versatile Tool for Teaching Exact Sciences

Mathematica CalcCenter 3: Web Presentation
<http://vega.fifi.cvut.cz/docs/mathus05/>

Thank you for your attention



END

To repeat the movie click **REWIND**