



# Enhancing the Classroom

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# Agenda



Challenges for Technical Courses



Requirements for Technical Courses



Exploring Maple



Exploring MapleSim



Exploring Maple T.A.

## Challenges Specific to Technical Programs

- Notation – display of mathematical symbols
- Meaning - mathematical ambiguity
- Visualization – graphs, diagrams, animations
- Exploration – concepts and processes
- Assessment – homework, help comprehension

**NOTATION** – display of mathematical symbols has always been one of the stumbling blocks for STEM programs. In Science, Technology, Engineering, and Mathematics, we don't just use words and numbers. We use special symbols. The challenge we face with notation is two-fold: the display doesn't look the way we want/expect and entering the expressions takes effort.

**VISUALIZATION** – including images in our teaching is very important to help students understand the concepts. The problem is that the images we can create are not always representative of the expressions and what if we want to make a small change in the expression. How can we talk about “What if...?”

**EXPLORATION** – in order to learn, students need to explore and practice, they need encouragement, and they need feedback. With the increased demands on instructors' time and increased class sizes, how can you provide the same level of interaction for your students?

**ASSESSMENT** – you are expected to provide learning opportunities for your students, but aren't given the support staff needed to grade assignments and work through problems with students. In addition, course management systems offer some assessment capabilities, but are not comprehensive enough for STEM programs.

# Requirements for Technical Programs

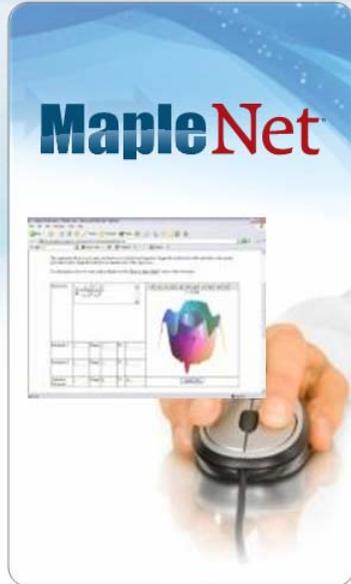
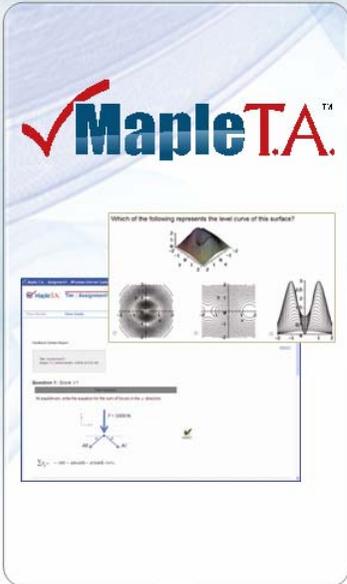
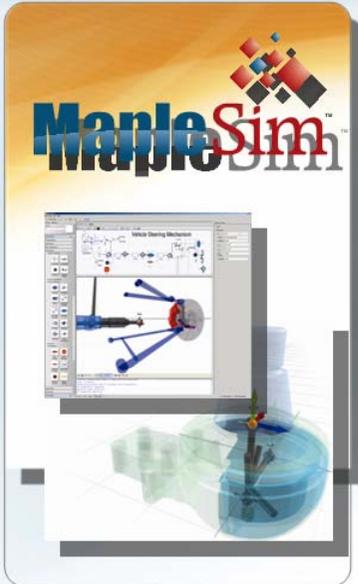
## Instruction

- Display capabilities
- Computerized algebra and calculus
- Visualization and animation
- Exploration tools
- Easy to use and explain
- Publishing and Web tools
- Content – e-books, worksheets, etc.

## Testing and Assessment

- Intelligent assessment of mathematics
- Randomization
- CMS integration
- Content

# Maplesoft Education Solutions



**Precalculus**  
Interactive Study Guide

**Advanced Engineering Mathematics with Maple**

**The Mathematics Survival Kit**  
Maple Edition  
How to Get an A+ in Math

**Calculus** [study guide]

**GRIDComputing**

**Maple Global Optimization Toolbox**



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**Maplesoft**  
Mathematics • Modeling • Simulation

## **Our educational product stack.**

Maple is the platform on which our other products are built:

- MapleSim is our physical modeling and simulation platform that connects the rigour of theory to physical systems students can understand.
- Maple T.A. is our automated testing and assessment platform.
- MapleNet lets you deploy Maple documents online and harness the full power of Maple from any typical browser.
- There are also a number of e-books and add-ons that bring value to you and your students.

Maple:

Power Mathematics

Flexible Interface (Clickable Math, Document Interface)

Passionate User Community

MapleSim:

Powerful Modelica Platform

White-Box Modeling and Analysis

Extremely Fast Auto Generated Model Code

Maple T.A.

Testing and Assessment designed especially for STEM

# Exploring Maple – Fundamental Mathematics

Deep Mathematics

$$\int f(x) dx = \int \lim_{n \rightarrow \infty} \frac{b-a}{n} \sum_{k=1}^n f\left(x + \frac{b-a}{n}k\right)$$

$$= (-m_p \tan(\theta)) \left[ r - \frac{r^2}{4r} + r \left( \cos(\omega t) + \frac{r}{4r} \cos(2\omega t) \right) \right]$$

$$x = R_1 e^{i\left(-\omega t + \sqrt{1-\epsilon^2}\right)} + R_2 e^{-i\left(-\omega t + \sqrt{1-\epsilon^2}\right)}$$

$$w_p = \int_{t_0}^t f_p dt = \int_{t_0}^t \left[ \dots \right]$$

2 output(s), 1 input(s)  
 inputvariable = [v(x)]  
 outputvariable = [0(x), t(x)]

$$if_{1,1} = \frac{JL^2 + (bL + JR)^2 + (bR + JL)^2}{4L}$$

Plots showing a 2D graph with multiple curves and a 3D plot of a spiral.

Clickable Math™  
Functionality

$$\int f(x) dx = \int \lim_{n \rightarrow \infty} \frac{b-a}{n} \sum_{k=1}^n f\left(x + \frac{b-a}{n}k\right)$$

$$= (-m_p \tan(\theta)) \left[ r - \frac{r^2}{4r} + r \left( \cos(\omega t) + \frac{r}{4r} \cos(2\omega t) \right) \right]$$

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$$w_p = \int_{t_0}^t f_p dt = \int_{t_0}^t \left[ \dots \right]$$

3D plot of a red surface.

Diagram of a rectangle with dimensions 18 cm and 30 cm.

Smart Document  
Environment

$$\int f(x) dx = \int \lim_{n \rightarrow \infty} \frac{b-a}{n} \sum_{k=1}^n f\left(x + \frac{b-a}{n}k\right)$$

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$$w_p = \int_{t_0}^t f_p dt = \int_{t_0}^t \left[ \dots \right]$$

Interactive plots and a control panel with various settings.

Extensive Education  
Resources

$$\int f(x) dx = \int \lim_{n \rightarrow \infty} \frac{b-a}{n} \sum_{k=1}^n f\left(x + \frac{b-a}{n}k\right)$$

$$= (-m_p \tan(\theta)) \left[ r - \frac{r^2}{4r} + r \left( \cos(\omega t) + \frac{r}{4r} \cos(2\omega t) \right) \right]$$

$$x = R_1 e^{i\left(-\omega t + \sqrt{1-\epsilon^2}\right)} + R_2 e^{-i\left(-\omega t + \sqrt{1-\epsilon^2}\right)}$$

$$w_p = \int_{t_0}^t f_p dt = \int_{t_0}^t \left[ \dots \right]$$

3D plot of a red surface.

2D plot of a curve with a shaded area.

All our products and solutions are based on two core technologies that are unique to Maplesoft – the world’s most advanced symbolic computation engine, and Clickable Math - the conviction that math software should be so simple to use that teachers and students can focus on the mathematics, not the tool.

Deep mathematics – over 4000 mathematical functions providing numeric and symbolic solutions in a wide variety of areas from algebra and calculus to differential equations and plotting

“Clickable Math” – over 100 easy-to-use commands and techniques. Allows for visual, interactive problem solving and make students instantly productive and engaged.

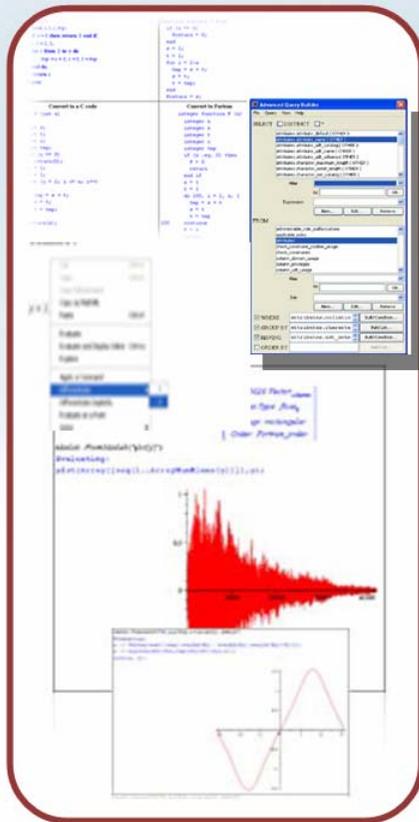
Smart document environment – produces rich documents that are fully interactive and as professional looking as a textbook. Combine text, math, and images together seamlessly.

Extensive education resources – Assistants (15+), tutors (50+), task templates (300+), mini demonstrations (49)



# Exploring Maple

## Clickable Math™ Functionality



- 100+ commands are accessible at your fingertips
- Allows for visual, interactive problem solving
- Easy to use
- Focus is on mathematics not software

# Exploring Maple

## Smart Document Environment

The screenshot displays the Maple Smart Document Environment. At the top, a graph shows a blue sine wave with a red vertical line at x=0. A context menu is open over the graph, listing options such as 'Out', 'Copy', 'Copy Full Precision', 'Paste', 'Style', 'Symbol', 'Line', 'Color', 'Transparency', 'Axes', 'Legend', 'Title', 'Scaling Constrained', 'Manipulator', 'Export', and 'Symbol Size...'. The 'Symbol' menu is expanded, showing options like 'Asterisk', 'Diagonal Cross', 'Box', 'Box (Solid)', 'Circle', 'Circle (Solid)', 'Cross', 'Diamond', 'Diamond (Solid)', 'Point', and 'Default'. Below the graph is a control panel for the 'Fundamental Frequency' calculation, featuring various sliders and buttons. At the bottom, mathematical formulas are displayed, including the Fourier series expansion of a square wave:

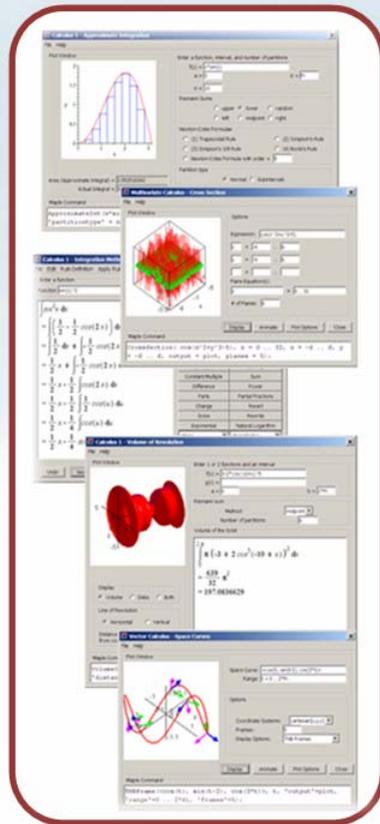
$$f(x) = \frac{1}{2} - \frac{1}{\pi} \sum_{n=1}^{\infty} \frac{\sin(n\pi x)}{n}$$

$$f(x) = \frac{1}{2} - \frac{1}{\pi} \left( \sin(\pi x) + \frac{\sin(3\pi x)}{3} + \frac{\sin(5\pi x)}{5} + \dots \right)$$

- Allows you to create fully interactive, professional looking documents or math apps
- Documents are readily shareable

# Exploring Maple

## Extensive Education Resources

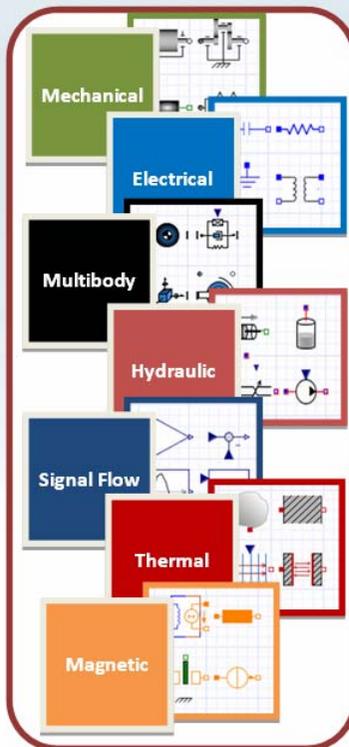


- 15+ Assistants
- 50+ Tutors
- 300+ Task Templates
- 49 Mini-Demonstrations

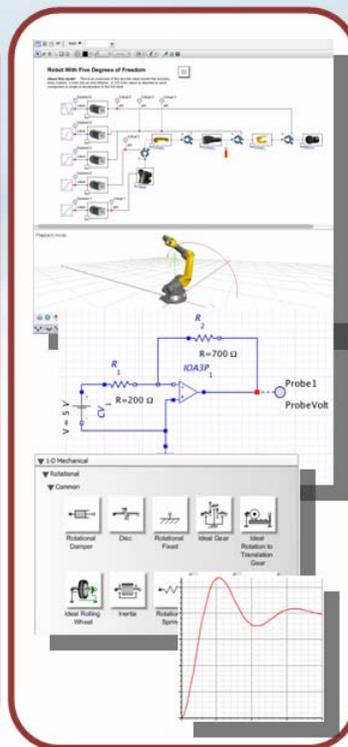
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# Exploring MapleSim – System Level Modeling

Multidomain Environment



Easy to Use Schematic Interface



Symbolic Representation

## System Equations

$$L \left( \frac{d}{dt} i(t) \right) = -R i(t) - u(t) - k \left( \frac{d}{dt} \phi(t) \right) \quad (2.1)$$

$$J \left( \frac{d^2}{dt^2} \phi(t) \right) = -b \left( \frac{d}{dt} \phi(t) \right) + k \phi(t) \quad (2.2)$$

## Rotational Spring Damper

Linear 1-D rotational spring and damper

Range\_3 Range\_3

## Description

This component consists of a spring and damper connected in parallel. It can be connected either between two inertias or gears to describe the shaft elasticity and damping, or between an inertia or gear and the housing (that is, the **Rotational Fixed** component) to describe a coupling of the element with the housing using a spring or damper. The component equations are

$$\begin{aligned} \phi_{in} &= \phi_s = \phi_d = \phi_{out} & \tau &= \tau_s & \tau_s + \tau_d &= 0 \\ \phi_{in} &= \phi_{out} & \tau &= c (\phi_{in} - \phi_{out}) + d \dot{\phi}_{in} \end{aligned}$$

Closed loop transfer function for the following feedback system is

$$\frac{G_{cl}(s)}{1 + G_{cl}(s)}$$

$$G_{cl}(s) = K_p + \frac{K_I}{s} + K_d s$$

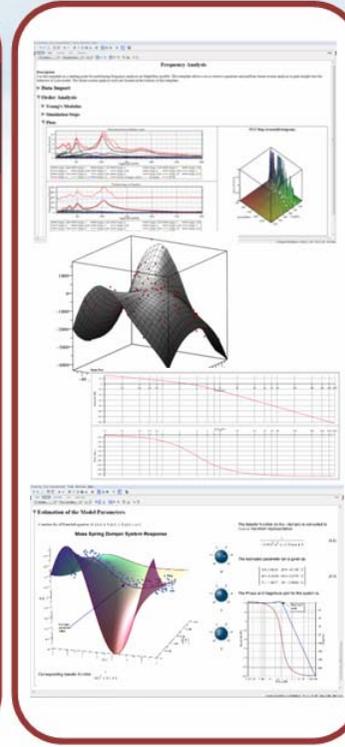
$$G_1 = \frac{k}{JLs^2 + (bL + R.J)s^2 + (R.b + R^2)s}$$

ProcSystem(7Fclosedloop)

## Transfer Function

continuous  
1 output(s), 1 input(s)  
signature = [1,1,1]  
outputvariable = [y,1(t)]  
 $\frac{kKd s^2 + kKp s + kKi}{JLs^2 + (bL + R.J)s^2 + (R.b + R^2)s}$

Optimization and Analysis



## Exploring MapleSim – System Level Modeling

Multidomain and multibody systems, plant modeling, control design – in one environment

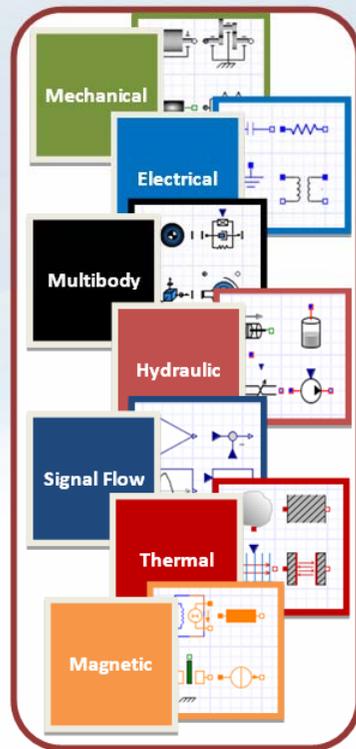
Easy to use, schematic diagram interface for rapid model development

Symbolic foundation provides highly concise, numerically efficient model formulation

Leverages the power of Maple for extensive optimization and analysis capabilities

# Exploring MapleSim

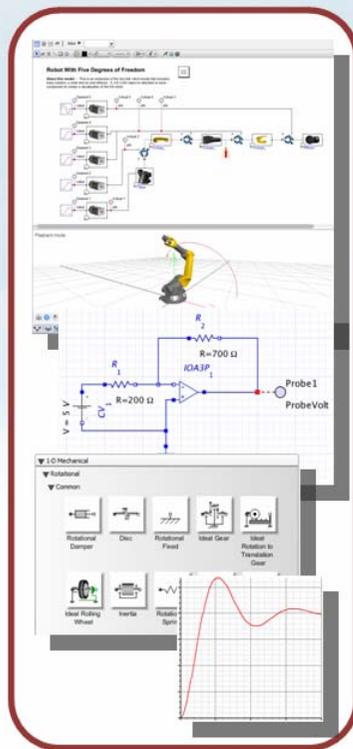
Multidomain  
Environment



- Multidomain and multibody systems in one environment
- Enables introducing and exploring multidisciplinary concepts
- Build realistic designs
- Investigate system-level interactions

# Exploring MapleSim

Easy to Use  
Schematic Interface



- Schematic diagram interface
- Drag and drop elements – over 400 components available
- Connect physically meaningful elements, like motors and gears
- Provides rapid model development

# Exploring MapleSim

## Symbolic Representation

### System Equations

$$L \left( \frac{d}{dt} i(t) \right) = -R i(t) - u(t) - k \left( \frac{d}{dt} \theta(t) \right) \quad (2.1)$$

$$J \left( \frac{d^2}{dt^2} \theta(t) \right) = -b \left( \frac{d}{dt} \theta(t) \right) + k i(t) \quad (2.2)$$

### Rotational Spring Damper

Linear 1-D rotational spring and damper

flange\_a  flange\_b

### Description

This component consists of a spring and damper connected in parallel. It can be connected either between two inertias or gears to describe the shaft elasticity and damping, or between an inertia or gear and the housing (that is, the **Rotational Fixed** component) to describe a coupling of the element with the housing using a spring or damper. The component equations are

$$\begin{aligned} \phi_{flange_a} &= \phi_b - \phi_a & \tau &= \tau_b & \tau_a &+ \tau_b = 0 \\ \phi_{flange_b} &= \phi_{flange_a} & \tau &= c (\phi_{flange_a} - \phi_{housing}) + d \omega_{flange_a} \end{aligned}$$

Closed loop transfer function for the following feedback system is

$$\frac{G_2 G_1}{1 + G_2 G_1}$$

$$G_2 = K_D + \frac{K_I}{s} + K_I s$$

$$G_1 = \frac{k}{JL^2 + (bL + R.J)^2 + (Rb + k) s}$$

PrintSystem(TFclosedloop)

### Transfer Function

continuous

1 output(s), 1 input(s)

numerator = [a[s]]

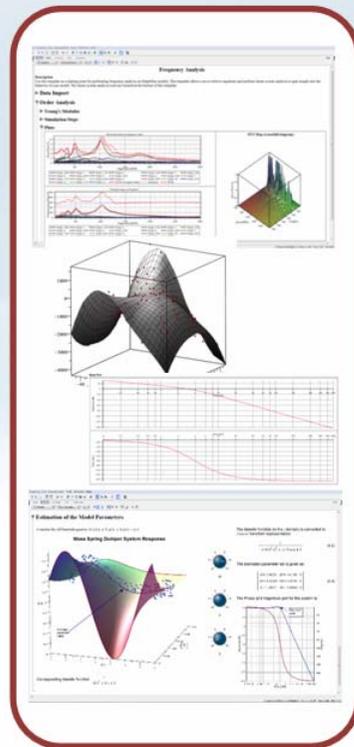
denominator = [y[s]]

$$T_{cl} = \frac{kK_I s^2 + kK_D s + kK_I}{JL^2 + (bL + R.J)^2 + (Rb + kK_D) s^2 + kK_D s + kK_I}$$

- Based on symbolic foundation, which provides highly concise, numerically efficient model formulation
- Access to system equations
- Build custom components from mathematical equations

# Exploring MapleSim

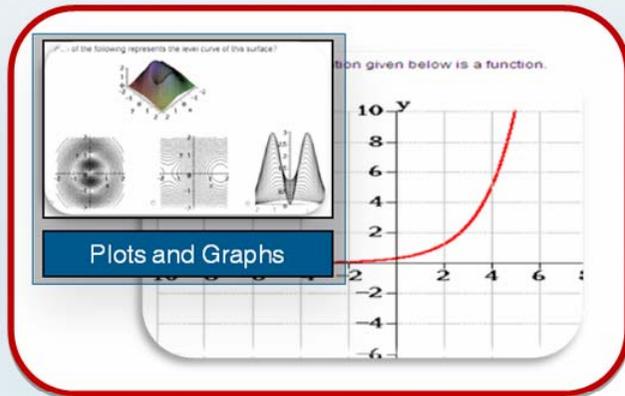
## Optimization and Analysis



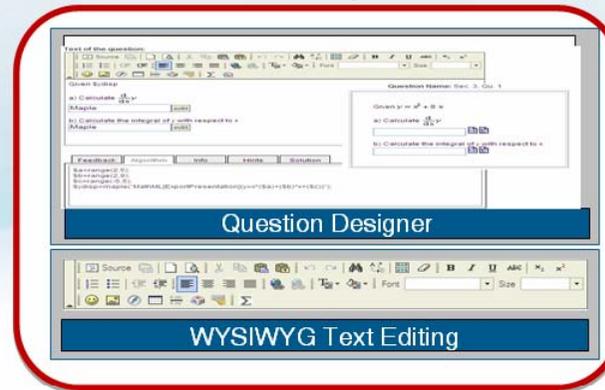
- Access to the power of Maple
- Optimization and analysis of design
- Demonstrate concepts such as parameter optimization, sensitivity analysis, and control design

# Exploring Maple T.A. – Testing and Assessment

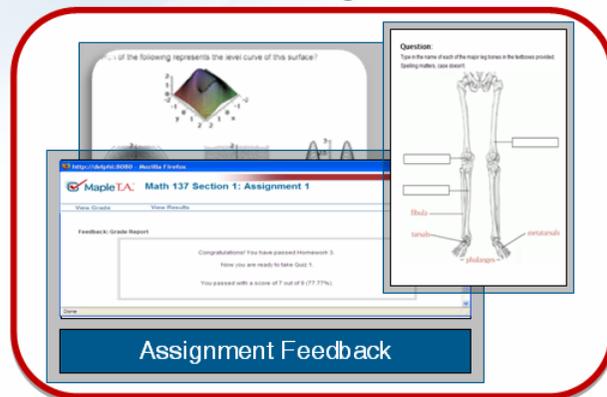
Access power of Maple



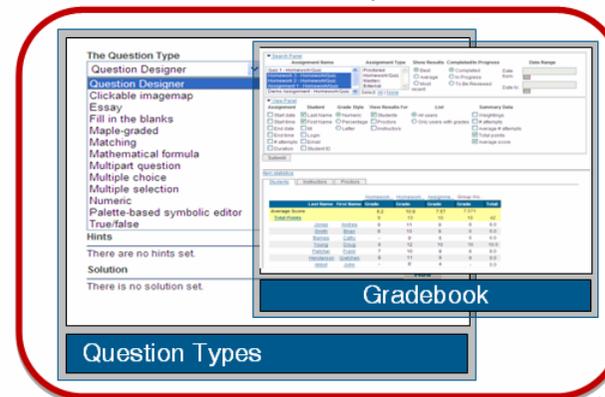
Intuitive authoring environment



Flexible assignments



Monitor students performance



Maple T.A. is an online testing and assessment system that is designed for any course that involves mathematics. It supports mathematical notation, plots, intelligent grading of free-response questions, and flexible algorithmic question generation.

Access power of Maple – you can use the power of Maple to create variables, plots, and grade student responses based on true mathematical equivalence

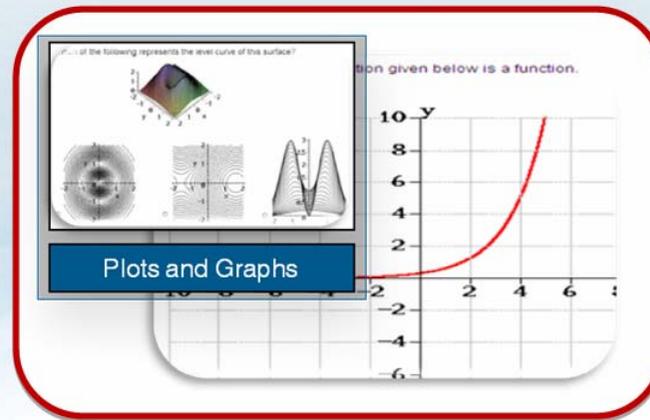
Intuitive authoring environment – not only does Maple T.A. provide all the question types available in standard testing systems (like multiple choice and fill-in-the-blank), but it also provides an authoring environment where you can build your own questions your way.

Flexible assignments – there are 5 distinct assignment types and you can provide feedback immediately, while the questions and concepts are fresh in students' minds.

Monitor student performance – the gradebook allows you to see the results of your class on an assignment basis, a question-by-question basis, or even a final mark based on weightings of specific assignments.

# Exploring Maple T.A.

Access power of Maple

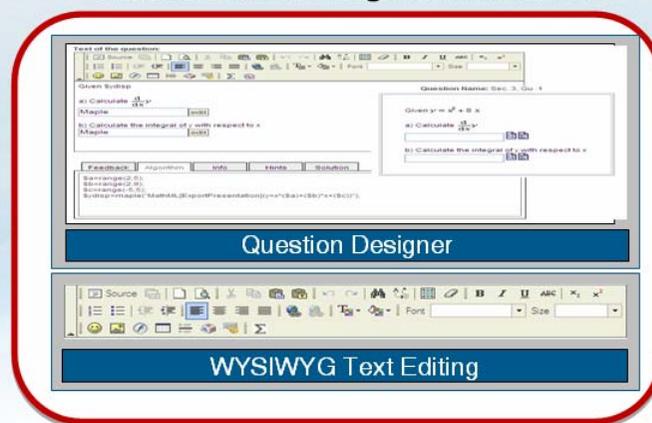


- Intelligent assessment of free-form responses and open-ended questions
- Mathematical notation
- Support for plots – 2D, 3D, and animations
- Algorithmic variable creation

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# Exploring Maple T.A.

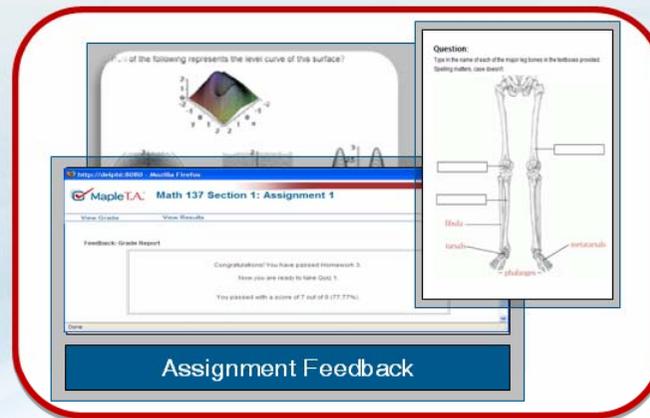
Intuitive authoring environment



- Variety of question types
- Include fonts, formatting, and images
- Algorithmic question capability
- Question sharing between instructors

# Exploring Maple T.A.

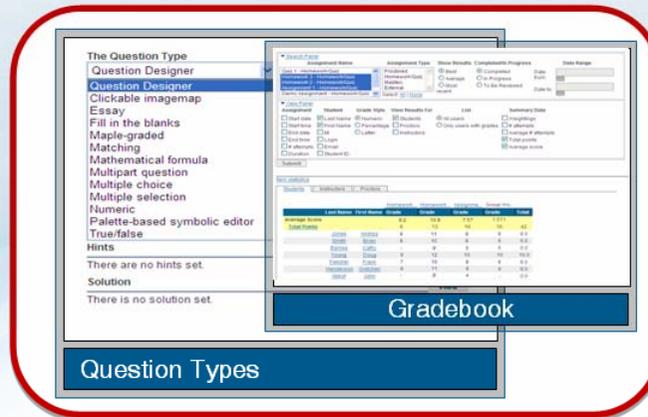
## Flexible assignments



- Assignment types for practice, homework, quizzes
- Customizable feedback options
- Question grouping
- Flexible scheduling
- Secure assessments

# Exploring Maple T.A.

Monitor students performance



- Automatic grading and immediate feedback
- Access to individual results
- Analysis of results
- Report generation and export

## Real-World Success – Case Studies



Many schools are using Maplesoft technology to revolutionize the way they teach technical courses.

Explore some of the academic user case studies on our website – various universities and schools around the world and how they are using our technology.

## Benefits of Technology

- Create an engaging, interactive classroom environment
- Increase student comprehension
- Link education to real-world examples
- Deepen understanding and develop analysis skills
- Minimize preparation time
- Provide immediate feedback
- Facilitate learning

## Conclusion

- Technical (or STEM) courses have unique challenges but there are effective tools and techniques to overcome them
- The Maplesoft experience integrates fundamental math, state-of-the-art physical modeling, and online testing and assessment

