Using Maple and Maple TA in a Course about Technical Computing

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Course Goal and Themes

- For engineering students to become proficient with an industrial grade tool including symbolics, numerics, visualization and scripting that they can use for engineering computation
- Design, Exploration, and Simulation
- Required of all freshmen engineering students (~700/year)

Course Objectives

- Be able to
  - Use a CAS to perform mathematical calculations
  - Use programming constructs and data structures to accomplish tasks and to automate computations
  - Use documentation and code libraries, test for correctness, and organize and reuse previous work
  - Determine when a result is correct (reasonable) and know what to do when things go wrong
  - Write scripts to set up a problem, explore a design space and simulate the behavior of a model
  - Explore concepts, form conjectures and test hypotheses

Course Organization

- 1 credit hour per term, 3 terms (30 weeks)
- Separate from calculus (math content lags behind one term)
- Meet 2 hour in weeks 2,4,6,8 in lab
- Automated quizzes (Maple TA, web based) in weeks 3,5,7,9 (on-line, any time)
- Exam in week 10 (Maple TA, proctored – 35%)
- Staff: 1 or 2 senior instructors, 4 or 5 instructors (auxiliary and grad TA), 6 undergrad assistants

Lab Format

- Prelab readings and quiz (new)
- Brief introduction to key concepts and themes
  - Powerpoint presentation
- Mixture of tutorials (examples) and problems
  - Teach by example and through problem solving
  - Work in small groups
  - Monitored by instructor and lab assistants
  - Lab verification (new)
- Followup quiz
  - Online (with Maple, feedback, and no time limit)

Core Functionality

- Basic expressions
  - variables, symbols, numbers,+-*/^, functions, eval, evalf
- Math solvers
  - solve, fsolve, diff, int, optimization, sum
- Visualization
  - plot, pointplot, display, animate
- programming
  - if, for, while, proc...end, ->, unapply, lists, sequences
- Use it repeatedly in Labs

Computation Lab I Overview '07

- Tutorial Introduction to Maple
  - Worksheet interface, expressions, evaluation,
- Equation Solving and Plotting
  - Numeric vs. symbolic
- Curve Fitting
  - Lists and sequences
- Introduction to Programming
  - Loops and conditionals
- Random walk

Computation Lab II Overview '07

- Differentiation and Newton's Method
- Solving Global Optimization Problems in Maple
- Running and Analyzing Computational Simulations of Random Walks
- Working with Data

Computation Lab III Overview '07

- Integration
- Optimal Driving (Fuel Consumption Model)
- Computer Simulation of Projectile Motion
- Autonomous Driving, part 2 (Driving Simulator)

What Went Well '07

- Regular evaluation and feedback under realistic conditions through Maple TA
- Demonstrated value of symbolic computation beyond labor saving device for calculus problems.
  - Unit conversion, piecewise functions, plotting formulas
- Sequence of labs allowed reinforcement and reuse of material and code
- Value of scripting for reuse and more extensive exploration
- Benefited from 1 term gap between math courses

What Did Not Go Well '07

- Mistakes led to frustration and difficulty recovering (syntax errors, cryptic error messages, debugging skills)
- Example based teaching students
  - More guidance needed for some students
  - Be more explicit in conveying relevance to engineering
- "One-size fits all"
  - Difficult to find that right level of difficulty for such a wide range of students
  - Difficult to find labs equally stimulating for such a wide range of students
  - Time required not uniform – students who did not complete the labs missed punch line and fell behind
- Maple TA had some technical issues and it was time consuming to create questions

Future Plans ‘07

- Make objectives and value to students clearer upfront
- Ease into syntax through click and point interface
- Gentler introduction to programming (more examples and lecture materials)
- Better documentation geared for beginning engineering students
- Better integration of course materials, documentation, and evaluation environment
- Better programming tools and environment
- Better diagnostic and remediation tools
- More engineering examples and better coordination with rest of curriculum

Changes ‘08

- Used document interface
- Ease into syntax through click and point interface
  - First term concentrated on Maple commands & document interface
- Gentler introduction to programming
  - Second term focused on introduction to programming
  - Scripts for engineering design, simulation and exploration
  - More explicit discussion of testing and debugging
  - Used editable code regions
- Written materials with detailed explanation and multiple examples and introduced prelabs
- Better assessment of learning (new version of Maple TA)
  - Lab verification sheets – no more “cut & paste and enter”
  - Greater use of randomized testing
- More explicit discussion and e.g. of Engr. Design

Computation Lab I Overview '08

- Introduction to Technical Computing and Maple
  - Document interface, expressions, evaluation
- Equation Solving and Plotting
  - Numeric vs. Symbolic
  - User defined functions
- Mathematical Document Preparation
- Introduction to Data Analysis
  - Elementary data structures
- Introduction to Engineering Design

Computation Lab II Overview '08

- More Mathematical Computation in Maple
  - Differentiation, Limits and Integration
- Writing Scripts
  - Programming Constructs
  - Testing and Debugging
- Solving Optimization Problems in Maple
- Chemical Reactions and Particle Simulation

Computation Lab III Overview '08

- Data Analysis (Knex Car)
- Computer Simulation of Projectile Motion (Blammo the Human Cannonball)
- Automobile Propulsion Model
- Autonomous Driving (Driving Simulator)

Sample Lab (Blammo)

- Reading
- Preview Slides
- Worksheet
- Quiz

Sample Quiz Question

https://mta.cs.drexel.edu:8443/mapleta/modules/classEditor.DisplayQuestion?actionID=display&questionbankName=CS 1

Maple T.A.

Grade | Refresh | Close

Question Bank: CS 123 Sp 09 Quiz 2 - Combined
Description: *Hit Blammo!*

Jump To: Question | Information Fields

Question:

Blammo is shot at a net 510 meters away from a cannon angled at 0.610865 radians. The net is 25 meters wide. At what initial velocity will Blammo hit the net?

Note: Include at least 4 digits after the decimal point.

Information Fields:

No fields set

Sample Quiz Question

https://mta.cs.drexel.edu:8443/mapleta/modules/unproctoredTest.InSessionGradeReport

MapleT.A.

Close

Question 3: *Score 1/1*

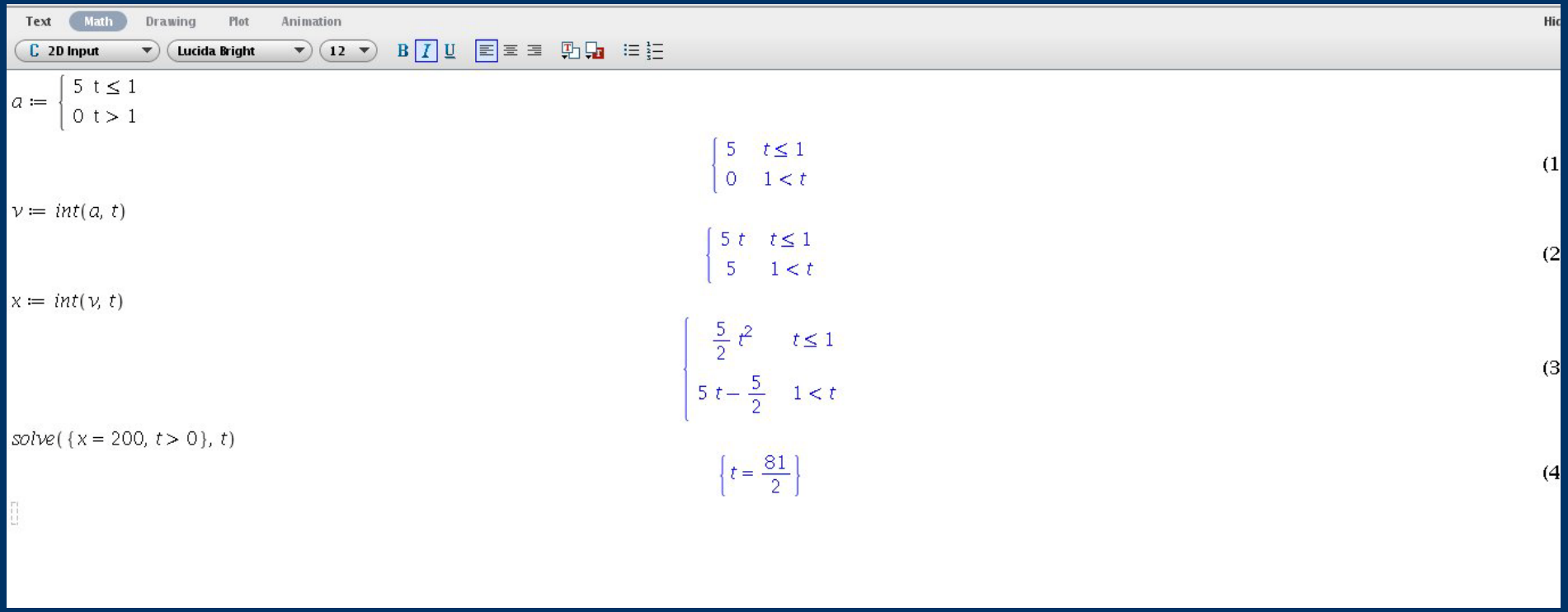
Your response

A sprinter in a 200 m race explodes out of the starting block with an acceleration of $5\ \frac{m}{s^2}$, which she sustains for $1\ s$. Her acceleration then drops to zero for the rest of the race. What is her time for the race? Compute the time to 5 significant digits.

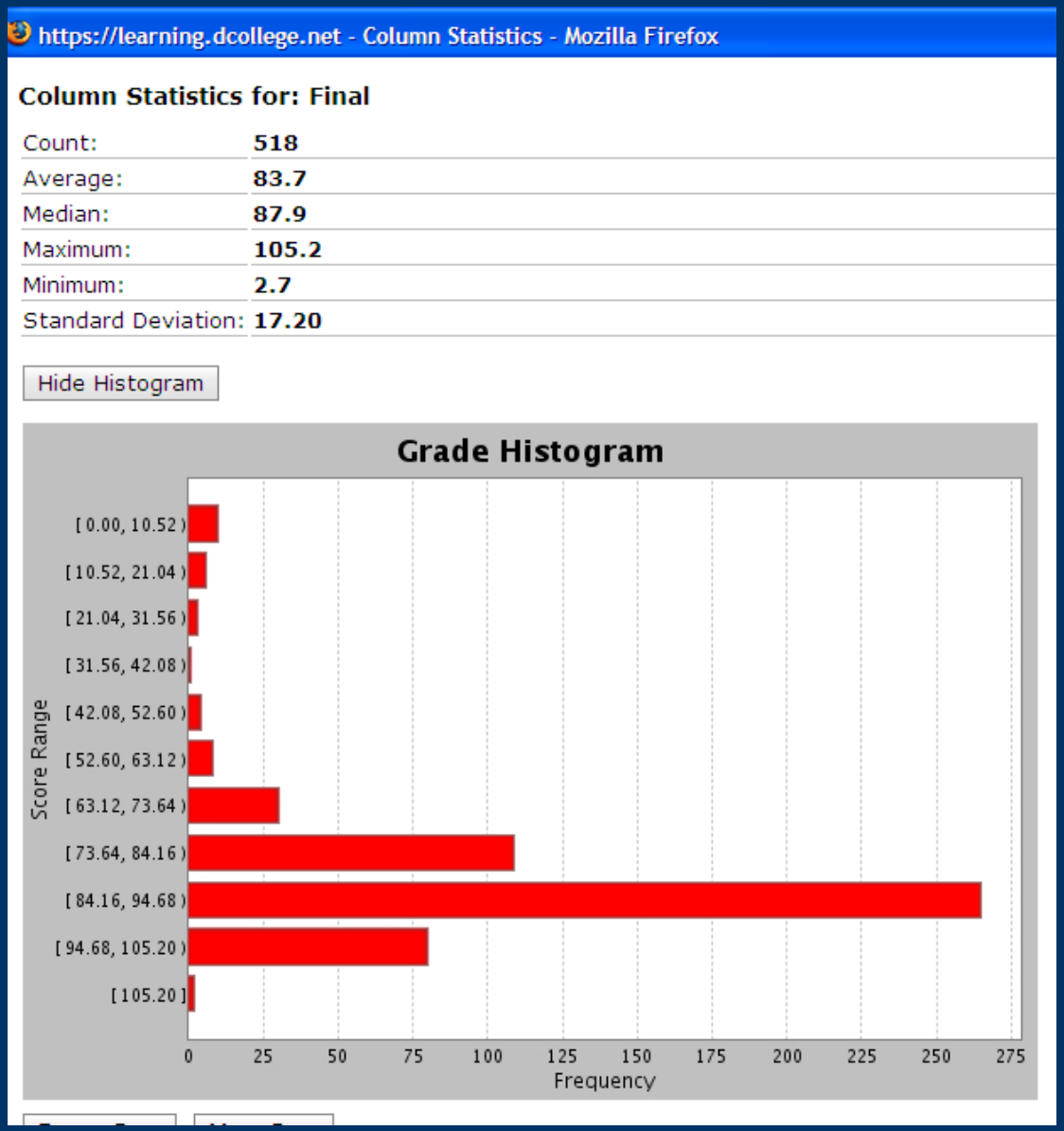
CORRECT

81/2 (100%)

Sample Quiz Scratch Work



Student Performance ‘07



Core competency demonstrated, though there is a significant tail

Evidence (“how did I do”) that quizzes used as a learning tool

However, for difficult questions repeated on proficiency exam, a drop in performance observed

Student Performance ‘08

	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Proficiency exam
CS121	(44% 82%)	(45% 78%)	(40% 72%)	(43% 73%)	64.4%
CS122	(69% 85%)	(59% 80%)	(61% 81%)	(53% 84%)	62.8%
CS123	(71% 85%)	(69% 84%)	(69% 85%)	(72% 86%)	44.5%

	CS122	CS122	CS123
90%+	205	53	50
80%+	156	115	35
70%+	137	137	48
60%+	106	129	52
50%+	87	121	67
40%+	56	71	96
30%+	36	40	109
20%+	13	17	100
10%+	7	12	53

Future Desires & What's Next

- More diagnostic tools and better remediation
  - Proficiency based grading?
- Coordination with other Engr/Math/Sci courses
- Better management of quiz questions
  - Searchable with meta data (multiple versions)
- Maple/Maple TA improvements
  - Better programming support (esp. for novices)
  - Improved documentation and publication facilities
  - Continued development (bug fixes) of Maple TA
    - Improved scalability, verification, fault tolerance