A MAPLE® AUTO-TUTORIAL FOR ENGINEERING AND TECHNOLOGY STUDENTS

Charles R. Thomas
Purdue University
Department of Mechanical Engineering Technology
West Lafayette, IN 47907

Introduction

Maple is a symbolic computational software package or a computer algebra system which has diverse applications as a problem solver tool. Maple can apply both analytical or symbolic methods and numerical methods. Maple is a software environment for doing mathematics: symbolic, numerical, and graphical activities and calculations are all possible. Maple capabilities include performing numerical calculations, defining and manipulating functions, performing symbolic calculations, solving algebraic equations, and plotting results.

The Maple auto-tutorial targets engineering and technology students. The primary objective of the auto-tutorial is for an individual to learn how to use Maple following an approach with a short learning curve. The basic goal is to get students up to an acceptable level of Maple proficiency in just a couple of hours of auto-tutorial utilization. Also, the auto-tutorial is an easy way for faculty to discover if they want to use Maple with their students and to get a quick peek at using the Maple software. Faculty can use the auto-tutorial template as it is or they can modify the template to accommodate almost any computational course in engineering, science, or technology. Modification could simply mean using a course specific equation for the target student group while keeping the basic format and flow of the current template.

Upon completion of the Maple auto-tutorial, the items learned and the capabilities developed by the user include making text comments, assigning numerical values to variables, creating and evaluating an equation, un-assigning values to variables, defining a function, evaluating the function at specific values, and finally plotting a graph of the function. Thus, the user finishes the auto-tutorial with a core set of Maple commands, tools, and abilities after just several hours of activity.

The Maple auto-tutorial was developed several years ago for use with first semester sophomore level students in a technology course. Computer programming or computer usage courses are not in the prerequisite course chain leading up to that course. Thus, while most students know how to use a computer, skills in using software such as Maple must be developed from scratch. While traditional, somewhat lengthy, learning techniques might include materials such as Maple Manuals[1, 2, 3], Maple textbooks[4, 5, 6], or even Maple supplements to standard textbooks[7, 8], the auto-tutorial approach does not require that students use any of these resource materials. Thus, core Maple skills are acquired in just a few hours rather than the much longer introduction necessitated with the inherent scatter of needed items often involved with a manual or textbook learning approach. Of course, the instructor developing the auto-tutorial materials and the more advanced student may find such references extremely useful.

The Auto-Tutorial

The auto-tutorial package consists of a set of instructions which cover three Maple scripts including a fully developed first script. The instruction sheets lead the students through the three Maple scripts and include questions at appropriate points which the students answer directly on the instruction pages. The instructions also request at appropriate points that students make a printed copy of each of the completed Maple scripts. The filled in

instruction sheets with the three Maple scripts attached are then submitted for grading.

The first part of the instructions leads the students through the typing of the fully developed Maple script named "Maple Exercise #1". The actual task is to work with a constant acceleration equation for displacement from either physics or dynamics, $s = v_0 t + \dfrac{a}{2} t^2$. This equation will be evaluated when $v_0 = 5$ ft/sec, $a = 10$ ft/sec/sec, and $t = 2$ sec. Since most engineering, science, or technology students have at least a physics course in their background, the selected equation simply serves as a vehicle for learning the Maple software.

The Auto-tutorial will now be developed with segments of the actual Maple script interspersed between segments of the instructions. Each Maple code or script line begins with the prompt symbol ">".

Maple Exercise #1

The first segment of the instructions is now given.

MET 000, Instructions for Maple Exercises #1, #1 – Revised, and #2, (30 points)

1. Find a PC computer on campus that has the Maple software installed.
2. Activate the Maple software and type in everything on the MET 000 Maple Exercise #1 sheet exactly as shown. However, do type in your own name and the current date. The actual text and formulas begin after the prompt symbols ">" which are part of the Maple Worksheet.
3. The plain text first line may be added by clicking on Insert+Paragraph+Before prior to doing the actual typing.
4. Click your mouse after the prompt symbol ">"on the next line to begin entering the Maple text of the second line.

5. Each line that begins with a comment sign or the sharp character, "#", is a line of plain, un-executable text.

A variable list consisting of the mathematical symbol, a verbal description, and appropriate units is given for each variable.

MET 000 Maple Exercise #1

> # **Maple Exercise #1**
> # **Your Name**
> # **MET 000**
> # **Date in 00/00/00 format**
> #
> # **Displacement equation for constant Acceleration**
> #
> # **Variable List**
> #
> #   **s - displacement at time t (ft)**
> #   **v0 - initial velocity (ft/sec)**
> #   **a - constant acceleration (ft/sec/sec)**
> #   **t - time (sec)**
> #
> # **The known or given values:**
> #
> **1: v0:=5;** $v0 := 5$

6. A line of executable code ends in a ";" semi-colon, the first line of executable code is the line 1: "v0:=5." The "1:" part of the line is a line number; we will use line numbers to reference and point to key lines. Line numbers are seldom actually used in Maple scripts; our current script would work exactly the same if the line numbers were omitted. The symbol ":=" is the assignment symbol. The formula assigns the value of 5 to the variable v0; thus when the variable v0 is used later in the code, it will still have the value of 5.

7. What happens when you click your mouse on the line 1: "v0:=5;" and then hit Enter? ($v0 := 5$ appears in blue) (1 point)

8. Notice that input lines are red, RED INPUT, and output lines are blue, BLUE OUTPUT.

To avoid direct links to Maple in the current paper, blue line entries have carefully been replaced with Mathtype entries. In Maple, red input lines are on the left and echoed blue output lines are on the right.

9. Type lines 2, 3, and 4 and hit Enter after each line. What are the value and the units of displacement? (30 ft) (2 points)

```
> 2: a:=10;      a := 10
> 3: t:=2;        t := 2
> # The displacement equation
> #
> 4: s:=(v0*t)+((a/2)*(t^2));     s := 30
> #####################
```

10. Type and hit Enter for lines 5, 6, 7, and 8 to un-assign the values defined above.

```
> # un-assign values defined above
> 5: v0:='v0';        v0 := v0
> 6: a:='a';          a := a
> 7: t:='t';          t := t
> 8: s:='s';          s := s
> #
```

11. The next executable line, line 9, defines displacement s as a function; hit Enter – a function s(t) is generated; t can now be any number and the displacement s(t) will be evaluated for that value of time.

```
> # a function definition of displacement s
> #
> 9: s:=t->(v0*t)+((a/2)*(t^2));
```

$$s := t \rightarrow v0t + \frac{1}{2}at^2$$

12. Type and hit enter for lines 10, 11, and 12; acceleration, time, and initial velocity are defined.

```
> # Displacements at different values of time using above function
> #
> 10: a:=10;         a := 10
> 11: t:=2;          t := 2
> 12: v0:=5;         v0 := 5
```

13. The next executable line, line 13, defines displacement at times 0, 1, 2, 3, and 4 seconds. Type and hit enter for this line to see the five corresponding displacements. What is the displacement at time 4 seconds? (100 ft) (1 point)

```
> #
> 13: s(0);s(1);s(2);s(3);s(4);  0 10 30 60 100
> #
```

14. Varying time over some range would be a parametric study in time. This can be visualized with a graph generated using the plot function in the next executable line, line 14. The time variable, tt, ranges from time 0 up to time 10 seconds. Type this line and hit Enter to see the graph plot. Is the plot a straight line or a curve? (curve) (2 points)

```
> #
> # a parametric study of changes in displacement "s" as time "t" varies
> #use new variable "tt" as time variable since "t" was already used above
> #
> 14: plot(s(tt),tt=0..10);
```
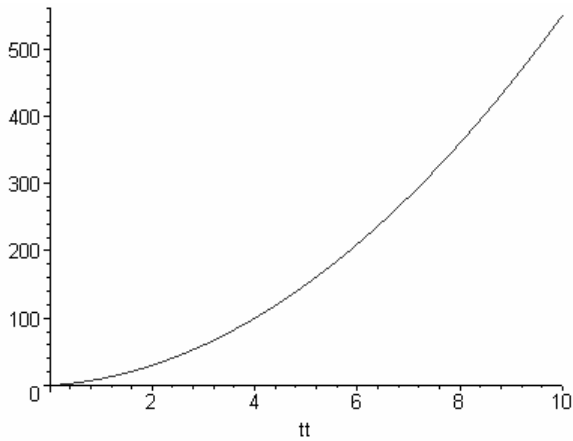
> # The End!

15. You can use the option Edit+Remove Output+From Worksheet to clear the BLUE OUTPUT and any extraneous values from the script or worksheet; going to the top of the script and repeatedly hitting enter yields a fresh run of the script.
16. You are now at the end of the Maple script or program. Use File+Save As to save your session file to a floppy disk, file name is your choice. Use File + Print to print a hard copy of the session just completed. All BLUE OUTPUT lines should be shown on this printed copy. This copy is to be attached to this handout prior to submission in class. (attachment) (4 points).
17. Maple provides on line help using the "?" Type and click on each of the lines with a "?" and read the corresponding Help information. How does the action of a ":" differ from the action of a ";" (":" does not display the result while ";" does display the result) (2 points).

> # Some Help pages, > ?, > ?;, > ?:, > ?:=,
    > ?=, > ?#, > ?->, > ?plot

Maple Exercise #1 - Revised

18. The Maple script that you have just typed can be used to solve new numerical problems by editing the input numbers. Modify Exercise #1 in two places to read Exercise #1 – Revised. Go back up to the first executable line

(v0:=5;) and modify the 3 input data values for an initial velocity of 7 ft/sec, an acceleration of 25 ft/sec/sec, and a time of 4 seconds. Hit Enter after each line is modified. What is the value of the displacement? (228 ft) (2 points).

Line numbers and comments are not included in this new script to avoid unnecessary redundancy.

MET 000 Maple Exercise #1 – Revised

> **v0:=7;** $v0 := 7$
> **a:=25;** $a := 25$
> **t:=4;** $t := 4$
> **s:=(v0*t)+((a/2)*(t^2));** $s := 228$

19. Also modify these new values in the function definition that is further down in the script. Hit Enter after each edit. Evaluate displacements in the next line at times 0, 2, 4 ,6, and 8. Hit Enter after the line of displacements. What is the displacement at time 8 seconds? (856) (2 points).

> **v0:='v0';** $v0 := v0$
> **a:='a';** $a := a$
> **t:='t';** $t := t$
> **s:='s';** $s := s$

> **s:=t->(v0*t)+((a/2)*(t^2));** $s := t \rightarrow v0t + \frac{1}{2}at^2$

> **a:=25;** $a := 25$
> **t:=4;** $t := 4$
> **v0:=7;** $v0 := 7$
> **s(0);s(2);s(4);s(6);s(8);** 0 64 228 492 856

20. Modify and run the line for the plot function line for a time interval of 15 seconds starting from time zero.

> **plot(s(tt),tt=0..15);**
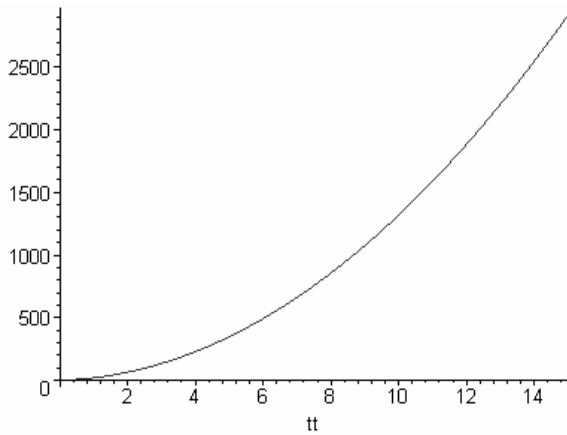
21. You are now at the end of the revised Maple script or program. Save a copy of this new file. Use File + Print to print a hard copy of the session just completed. All BLUE OUTPUT lines should be shown on this printed copy. This copy is to be attached to this handout prior to submission in class. (attachment) (4 points).

Maple Exercise #2

22. Write a new Maple script (or modify the existing Maple Exercise #1 script) to solve the velocity equation v = v0 + a*t. Name the script Exercise #2 in 2 places.

23. Assume an initial velocity of 12 ft/sec, an acceleration of 3 ft/sec/sec, and a time of 8 seconds. What is the final velocity under these last conditions? (36 ft/sec) (3 points).

```
> # Final Velocity equation for constant
  Acceleration
> #   v  - final velocity )ft/sec)
> #   v0 - initial velocity (ft/sec)
> #   a  - constant acceleration (ft/sec/sec)
> #   t  - time (sec)
> v0:=12;          v0 := 12
> a:=3;            a := 3
> t:=8;            t := 8
> v:=v0+(a*t);     v := 36
```

24. Un-assign the given values and enter a line for a functional definition of initial velocity. Assume an initial velocity of 12 ft/sec, an acceleration of 3 ft/sec/sec. Evaluate final velocities at times 0, 1, 2, 3, and 4 seconds.

```
> v0:='v0';          v0 := v0
> a:='a';            a := a
> t:='t';            t := t
> v:='v';            v := v
> v:=t->v0+(a*t);    v := t → v0 + at
> v0:=12;            v0 := 12
> t:=8;              t := 8
> a:=3;              a := 3
> v(0);v(1);v(2);v(3);v(4); 12 15 18 21 24
```

25. For the given data, what is the final velocity at time 4 seconds? (24 ft/sec) (2 points).

26. Run a parametric plot study of changes in final velocity as time varies from 0 to 12 seconds. Is the resulting plot a straight line or a curve? (straight line) (2 points).

```
> plot(v(tt),tt=0..12);
```
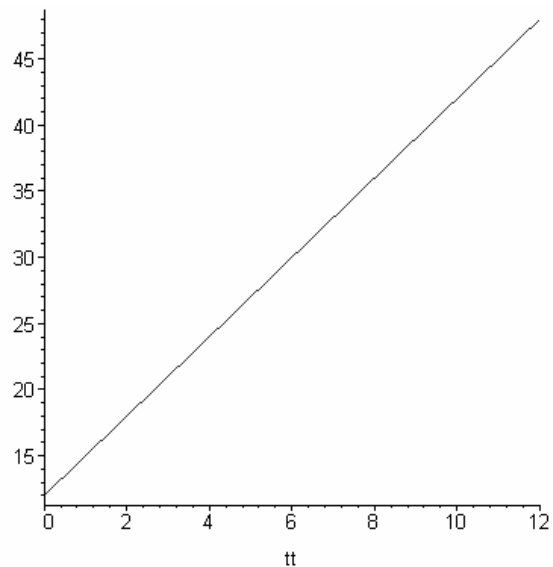

27. Save a copy of this new file. Use File + Print to print a hard copy of the session just completed. All BLUE OUTPUT lines should be shown on this printed copy. This copy is to be attached to this handout prior to submission in class. (attachment) (3 points).

Conclusions

A three part Maple auto-tutorial has been detailed. The first auto-tutorial part asked students to directly type into Maple an existing, working Maple script and then to run the script. The second auto-tutorial part asked students to simply change the given data and re-run the resulting Maple script, in this manner the script is used as a piece of problem solving software. The third auto-tutorial part asked the students to solve a new physics or dynamics equation by modifying the variables and the equation in the existing script.

The Maple scripts developed can actually serve as a template for the development of other Maple scripts for other computational course equations in engineering, science, or technology. With or without additional Maple commands and command options, the basic elements of a variety of Maple problem solving scripts have been covered in the auto-tutorial. A breakdown of the elements of the current Maple script includes making text comments, assigning numerical values to variables, creating and evaluating an equation, un-assigning values to variables, defining a function, evaluating the function at specific values, and finally plotting a graph of the function.

The basic format and structure of the auto-tutorial can easily be adapted to other courses and disciplines. Additional auto-tutorial commands and command complexity can be added to accommodate students who have a more extensive computer background. Additional auto-tutorial exercises can be developed and assigned to students who have completed or mastered the first auto-tutorial. A series of several progressively more complex auto-tutorial exercises can effectively and rapidly turn novice student computer users into reasonably proficient Maple problem solvers.

References

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Biographical Information

Charles R. Thomas is a Professor of Mechanical Engineering Technology at Purdue University and has been teaching at Purdue since 1976. He received the B. S. and M. S. degrees in Mechanical Engineering from Clarkson College in 1963 and 1966 respectively and an M. S. Degree in Mechanics from Rensselaer Polytechnic Institute in 1969. He has been the recipient of 10 awards for excellence in teaching and outstanding undergraduate teaching. Charles is the author of 36 journal articles and 76 conference and other publications in the areas of mechanics, solid mechanics, educational measurement, technical education, technology student characteristics, field-independence, the Myers-Briggs Type Indicator, technical computer applications, technical spreadsheet applications, spreadsheet programming, and spreadsheet macro programming.