Chapter 2: Introduction to Maple V

2-1 Working with Maple Worksheets

Try It! (p. 15)

Start a Maple session with an empty worksheet. The name of the worksheet should be *Untitled (1)*. Use one of the standard methods for your platform to maximize the worksheet (that is, expand the Maple worksheet so that it completely fills the window). The result should be very similar to Figure 2-1.

Solution

See Figure 2-1 on page 15 of the text.

Try It! (p. 16)

Activate balloon help in your current session. Then, use it to display the descriptions of each of the icons in the toolbar.

Solution

Follow the directions found in the text on page 16 immediately preceding this Try It! (p. 16).

Try It! (p. 17)

Use the toggle switches at the top of the View menu to see how the interface changes when various menu bars are hidden from view. When finished, be sure that all bars are visible.

Solution

See the discussion that immediately precedes this Try It! (p. 17)

This exercise is intended to familiarize you with Maple's interface and the terminology used to describe the different components of the interface. I recommend having all three icon bars visible at all times.

Try It! (p. 20)

Use the Copy and Paste method just described to complete the verification that the second solution satisfies the two equations.

Solution

```
> restart;
```

To get to a state from which it is possible to complete the Try It!, execute the following commands (from pages 17 -- 19):

```
> f := x^3 + x;
```

$$f := x^3 + x$$

```
> g := a*x^2;
```

$$g := a\,x^2$$

```
> df := diff( f, x );
```

$$df := 3\,x^2 + 1$$

```
> dg := diff( g, x );
```

$$dg := 2\,a\,x$$

```
> SOL := solve( { f = g, df = dg }, { x, a } );
```

$$SOL := \{a = 2, x = 1\}, \{x = -1, a = -2\}$$

```
> subs( SOL[1], [ a, x, f = g, df = dg ] );
```

$$[2, 1, 2 = 2, 4 = 4]$$

```
>
```

To verify that the second solution in SOL also satisfies the two equations, copy the previous line to an input region, change SOL[1] to SOL[2], and execute the command. The new command and its result should look like:

```
> subs( SOL[2], [ a, x, f = g, df = dg ] );
```

$$[-2, -1, -2 = -2, 4 = 4]$$

```
>
```

Try It! (p. 21)

Open the worksheet *first.mws* located on the Toolkit homepage. Compare this worksheet with the one you have just created, *myfirst.mws.*

Solution

See the worksheet *first.mws* that can be obtained from Addison-Wesley or from one of the authors (Meade). The relevant URLs are ftp://ftp.aw.com/cseng/authors/meade/first.mws and http://www.math.sc.edu/~meade/toolkit/first.mws.

Note to Publisher: Please confirm that the AW URL is/will be appropriate. What do you need to make this possible?

Try It! (p. 21)

To explore the ramifications of the fact that all worksheets within the same Maple session access the same Maple kernel, create a new worksheet (the default name should be called *Untitled (2)*.) Enter and execute the command `f;` in the new worksheet. The result should be the expression representing the function f that was entered in the worksheet now titled *myfirst.mws*. Note that even though there is nothing in *Untitled (2)* to indicate how f received a value, the result clearly shows that *Untitled (2)* is sharing information with *myfirst.mws*, and any other command executed within this Maple session.

Solution

The output from the command `f;` in *Untitled (2)* should be

$$x^3 + x$$

If you have not followed the text, you will likely see that there is no value assigned to the name `f`. In this case you should repeat enough of the discussion in the text to give a value to `f` in another worksheet.

Try It! (p. 23)

Use the `subs` command to determine the exact location of the second point of intersection for the derivatives. Are the answers you obtained in reasonable agreement symbolically and graphically? Why is this point not a solution to the tangency problem?

Solution

```
> restart;
```

The following assignments from the text are needed

```
> f := x^3 + x;
```

$$f := x^3 + x$$

```
> g := a*x^2;
```

$$g := a\,x^2$$

```
> G2 := subs( a=2, g );
```

$$G2 := 2\,x^2$$

```
> df := diff( f, x );
```

$$df := 3\,x^2 + 1$$

```
> dG2 := diff( G2, x );
```

$$dG2 := 4\,x$$

```
>
```

The intersection(s) of the derivatives can be found using

```
> solve( df=dG2, x );
```

$$\frac{1}{3}, 1$$

The intersection at $x = 1$ is the point of tangency discussed on page 22. The other intersection occurs at $x = \frac{1}{3}$ (this can also be estimated from the plot and the tools provided on the Maple interface).

```
>
```

To complete this exercise, examine the values of the functions and their derivatives at $x = \frac{1}{3}$. This produces:

```
> subs( x=1/3, [ f, G2, df, dG2 ] );
```

$$\left[\frac{10}{27}, \frac{2}{9}, \frac{4}{3}, \frac{4}{3}\right]$$

While it is obvious that f and $G2$ both have slope $\frac{4}{3}$ at $x=\frac{1}{3}$, the function values are not the same. Since the two functions do not intersect at the point $x=\frac{1}{3}$, this cannot be a point of tangency.

>

Try It! (p. 24)

The insertion of an execution group after the cursor and conversion of a region between text and input are used so often that shortcuts are provided on the tool bar. Use balloon help to locate the icons on the tool bar that correspond to a) inserting a new execution group after the cursor, b) inserting and formatting inert text, and c) inserting Maple commands in a text region.

Solution

These icons are
a) the 11th icon from the left in the tool bar ([>)
b) the 10th icon from the left in the tool bar (T)
c) the 9th icon from the left in the tool bar (\Sigma)

Note to Publisher: it would be nice to be able to include these icons as inserts in the IG. What do you need to make this possible?

2.2 Using Online Help

Try It! (p. 25)

The online help page that describes most features of the Maple worksheet can be accessed using help(worksheet);. Load this help document. Click the highlighted string Help System Guide. This opens another help document. Locate and read the information about searching the table of contents.

Solution

To get started, execute the following command

```
> help(worksheet);
```

Note: alternate methods of accessing online help

Two alternate methods of accessing the same help document are to click on this hyperlink or to execute the command

```
> ?worksheet
```

Note that the help command requires a semi-colon, the ? command does not. The only other command in Maple that does not require a semi-colon or colon is the quit command.

Following the instructions in the Try It!, you should see the following section (which was inserted into this worksheet via copy and paste) :

How do I search the table of contents?

Choose ***Contents*** from the ***Help*** menu. The ensuing help page is the top-level table of contents of the help system. Click on a hyperlink to see more details.

>

Try It! (p. 27)

Place the cursor on the word **plot** in the plot command toward the bottom of the *mysecond.mws* worksheet. Use context-based help to access the help for the plot command. Read this information, and the examples, to find out how to modify the **plot** command to cause f and f' to be displayed in blue and the graphs of g and g' in red.

Solution

To get an idea of how the worksheet *mysecond.mws* should appear, obtain a copy of the worksheet *second.mws* from Addison-Wesley or from one of the authors (Meade). The relevant URLs are http://www.awl.com/cseng/toolkit/modules/map/second.mws and http://www.math.sc.edu/~meade/toolkit/second.mws.

>

To complete this exercise, the following definitions are needed:

```
> f := x^3 + x;
```

$$f := x^3 + x$$

```
> g := a * x^2;
```

$$g := a\,x^2$$

```
> df := diff( f, x );
```

$$df := 3\,x^2 + 1$$

```
> G1 := subs( a=2, g );
```

$$G1 := 2\,x^2$$

```
> dG1 := subs( a=2, dg );
```

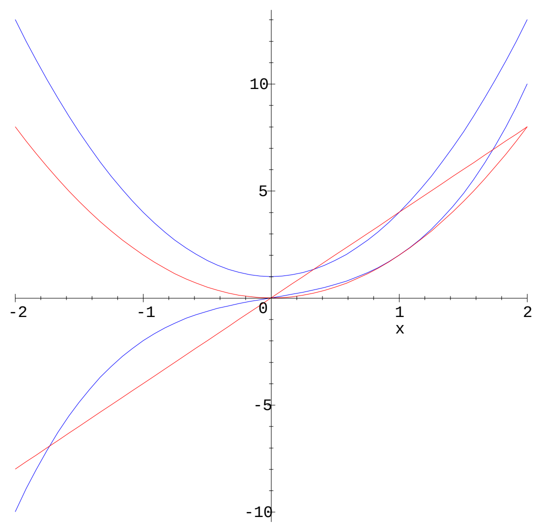
$$dG1 := 4\,x$$

>

To create the plot described in the Try It!, it is necessary to specify the color= option in the plot command. The final command and plot should look something like:

```
> plot( [ f, G1, df, dG1 ], x=-2..2,
>       color = [ blue, red, blue, red ],
>       title='Graphical verification when a=2' );
```

Graphical verification when a=2



>

What If? (p. 37)

Suppose the material is heated. How would this change the stress-strain curve? Would the toughness increase or decrease? Why?

Solution

As the temperature increases, the Young's modulus (E) decreases. As a result, assuming the strain is held constant, the stress ($\sigma = E\,\varepsilon$) also decreases. In terms of the stress-strain curve, the temperature increase will lower the curve. Since the lowering of the stress-strain curve reduces the area under the curve, the toughness will also be reduced.

2.3 Advanced Worksheet Features

Try It! (p. 38)

Open the worksheet[howto] help document. This worksheet contains a long collection of sections. Locate and expand the sections related to execution groups and to sections. Consult these references for detailed information about execution groups and sections.

Solution

The help document associated with the keyword worksheet[howto] can be accessed via any of the standard methods (hyperlink, help command, or ? command). For example,

```
> ?worksheet[howto]
>
```

The information about execution groups and sections has been copied here for your convenience.

Execution Groups

The ***execution group*** is the fundamental computation and documentation element for the worksheet. Each execution group is enclosed in a large square ***bracket*** at the left. The text you are reading now is embedded in an execution group. It can contain Maple input commands, the output from a Maple computation, explanatory text and graphics. Notice that an execution group may contain zero, one, or more Maple input commands. If you place the cursor in an input command and press [Enter], Maple V executes all the input commands in the current execution group.

How do I delete an execution group?

See the section on Deleting.

How do I enclose several execution groups in a section?

Highlight the execution groups that you would like to enclose in a section. Next, choose **Indent** from the **Format** menu.

How do I insert an execution group?

See the section on Inserting.

How do I insert text above an execution group?

Click the execution group bracket (the large square bracket to the left of the prompt(s)). Then choose **Paragraph** from the **Insert** menu and **Before** from the ensuing submenu.

How do I insert text below an execution group?

Click the bracket enclosing the execution group to select it. Then choose **Paragraph** from the **Insert** menu and **After** from the ensuing submenu.

How do I join execution groups?

See the section on Joining.

How do I remove an execution group from a section?

Position your cursor in the execution group that you would like to remove from a section. Next, choose **Outdent** from the **Format** menu.

How do I show (hide) execution group ranges?

By default, Maple V displays the execution group ranges. To hide them, select **Show Group Ranges** from the **View** menu. Notice that if you return to the **View** menu, the check mark beside **Show Group Ranges** has disappeared.

How do I split an execution group?

See Splitting.

Also see the sections on Deleting., Inserting, Joining, and Splitting.

Sections

A ***section*** is enclosed in a large square ***bracket*** with a box at the top.

How do I collapse a section?

With your mouse, click on the box ([-]) to the left of the section heading.

How do I collapse all the sections in a worksheet?

Choose **Collapse All Sections** from the **View** menu.

How do I delete a section?

See Deleting.

How do I enclose one or more execution groups in a section?

Highlight the execution groups that you would like to enclose in a section. Next, choose **Indent** from the **Format** menu.

How do I expand a section?

Click on the box ([+]) to the left of the section heading.

How do I expand all the sections in a worksheet?

Choose **Expand All Sections** from the **View** menu.

How do I insert a section?

See Inserting..

How do I join sections?

See Joining.

How do I show (hide) section ranges?

Choose **Show Section Ranges** from the **View** menu.

How do I split a section?

See Splitting.

>

Problems (pp. 41-42)

Problem 1

Repeat the graphical and symbolic verification that $a = -2$ is another solution to the tangency problem. Add these results, with appropriate documentation and explanation to the worksheet *mythird.mws*.

Solution

The worksheet third.mws presents one solution to this problem. A copy of the worksheet *third.mws* can be obtained from Addison-Wesley or from one of the authors (Meade). The relevant URLs are ftp://ftp.aw.com/cseng/authors/meade/third.mws and http://www.math.sc.edu/~meade/toolkit/third.mws.

Problem 2

Convert all textual mathematical expressions in the worksheet created in Problem 1 to inline math expressions. Also, in a new section at the end of the worksheet, create hyperlinks to the help documents for each of the Maple commands used in this worksheet and to the help documents most relevant to the interface features used in this worksheet. Call the resulting worksheet *myfourth.mws.*

Solution

The worksheet fourth.mws, available from Addison-Wesley or from one of the authors (Meade), provides one possible solution to this problem. The relevant URLs are ftp://ftp.aw.com/cseng/authors/meade/fourth.mws and http://www.math.sc.edu/~meade/toolkit/fourth.mws.

Problem 3

Create a new worksheet, called *reference.mws*, that contains links to examples and help and other introductory material. Use hyperlinks to create links to commonly accessed online help documents, including worksheet, worksheet[howto], worksheet[glossary], student, and help. As you progress through this module, you should update this worksheet with new links, summaries of main techniques, examples, and any other information you find useful.

Solution

A barebones version of the worksheet *reference.mws* can be downloaded from Addison-Wesley or from one of the authors (Meade). The relevant URLs are ftp://ftp.aw.com/cseng/authors/meade/references.mws and http://www.math.sc.edu/~meade/toolkit/references.mws.

Problem 4

Estimate the modulus of toughness of the composite material discussed in Application 2 when the area under the third segment of the stress-strain curve is approximated by two trapezoides with a common side of ε=5.3%. What is the corresponding error in the modulus of toughness, relative to the smallest estimate of the toughness? (What benefit is obtained by using the smallest estimate in this comparison?)

Solution

In preparation to answer this question we repeat the commands (with some minor simplifications) from the Application section of the text (pp. 29 -- 37)

```
> restart; with(student):
> pt1 := [0,0]:
> pt2 := [0.028,330]:
> pt3 := [ 0.032, 330 ]:
> pt4 := [ 0.053, 440 ]:
> pt5 := [ 0.074, 360 ]:
> E := ( pt2[2]-pt1[2] ) / ( pt2[1] - pt1[1] );
```

$$E := 11785.71429$$

```
> tough[elast] := evalf( 1/2 * ( pt2[1] - pt1[1] ) * ( pt2[2] - pt1[2] ), 2 );
> tough[const] := evalf( ( pt3[1] - pt2[1] ) * pt2[2], 2 );
> tough[min] := evalf( ( pt5[1] - pt3[1] ) * pt5[2], 2 ) ;
> tough[max] := evalf( ( pt5[1] - pt3[1] ) * pt4[2], 2 ) ;
```

$$tough_{elast} := 4.6$$

$$tough_{const} := 1.3$$

$$tough_{min} := 15.$$

$$tough_{max} := 18.$$

```
> Ttough[min] := evalf( tough[elast] + tough[const] + tough[min], 2 );
> Ttough[max] := evalf( tough[elast] + tough[const] + tough[max], 2 );
```

$$Ttough_{min} := 21.$$

$$Ttough_{max} := 24.$$

```
> Ttough[err] := ( Ttough[max] - Ttough[min] ) / Ttough[min];
```

$$Ttough_{err} := .1428571429$$

```
> QUAD := sigma = a*epsilon^2 + b*epsilon + c;
> EQ1 := evalf( subs( epsilon=pt3[1], sigma=pt3[2], QUAD ), 2 );
> EQ2 := evalf( subs( epsilon=pt4[1], sigma=pt4[2], QUAD ), 2 );
> EQ3 := evalf( subs( epsilon=pt5[1], sigma=pt5[2], QUAD ), 2 );
```

$$QUAD := \sigma = a\,\varepsilon^2 + b\,\varepsilon + c$$

$$EQ1 := 330. = .0010\,a + .032\,b + c$$

$$EQ2 := 440. = .0028\,a + .053\,b + c$$

$$EQ3 := 360. = .0055\,a + .074\,b + c$$

```
> SOLN2 := solve( { EQ1, EQ2, EQ3 }, { a, b, c } ):
> SOLN2 := evalf( SOLN2, 2 );
> stress := subs( SOLN2, rhs(QUAD) );
```

$$SOLN2 := \{c = -210., b = 23000., a = -210000.\}$$

$$stress := -210000.\,\varepsilon^2 + 23000.\,\varepsilon - 210.$$

```
> tough[quad4R] := rightsum( stress, epsilon=0.032..0.074 ):
> tough[quad4R] := evalf( tough[quad4R], 2 );
> Ttough[quad4R] := evalf( tough[elast] + tough[const] + tough[quad4R], 2 );
```

$$tough_{quad4R} := 18.$$

$$Ttough_{quad4R} := 24.$$

```
> tough[quad4T] := evalf( trapezoid( stress, epsilon=0.032..0.074 ), 2 );
```

$$tough_{quad4T} := 16.$$

```
> tough[quad4S] := evalf( simpson( stress, epsilon=0.032..0.074 ), 2 );
```

$$tough_{quad4S} := 17.$$

```
> Ttough[quad4S] := evalf( tough[elast] + tough[const] + tough[quad4S], 2 );
```

$$Ttough_{quad4S} := 23.$$

```
> error[min] := abs( Ttough[quad4S] - Ttough[min] ) / Ttough[quad4S];
> error[max] := abs( Ttough[quad4S] - Ttough[max] ) / Ttough[quad4S];
> error[quad4R] := abs( Ttough[quad4S] - Ttough[quad4R] ) / Ttough[quad4S];
```

$$error_{min} := .08695652174$$

$$error_{max} := .04347826087$$

$$error_{quad4R} := .04347826087$$

```
>
```

And, now, the solution of the current problem is found by obtaining the trapezoidal approximation to the toughness between $\varepsilon = .032$ and $\varepsilon = .074$. This is the same as the quad4T approximation except that the optional second argument of the trapezoid command must be used to indicate that only 2 trapezoids are to be used.

```
> tough[quad2T] := trapezoid( stress, epsilon=0.032..0.074, 2 ):
> tough[quad2T] := evalf( tough[quad2T], 2 );
```

$$tough_{quad2T} := 16.$$

The total modulus of toughness is

```
> Ttough[quad2T] := evalf( tough[elast] + tough[const] + tough[quad2T], 2 );
```

$$Ttough_{quad2T} := 22.$$

The relative error, compared to the lowest estimate, is

```
> error[quad2T] := abs( Ttough[quad2T] - Ttough[min] ) / Ttough[min];
```

$$error_{quad2T} := .04761904762$$

The computation of the error relative to the lowest estimate is not likely to underestimate the actual error. (This is a result of the fact that the denominator is smaller.)

```
>
```

Problem 5

This chapter used rightbox and rightsum to approximate the area under the quadratic curve with the default number of rectangles. How many rectangles are needed to approximate the area to four digits of accuracy. (Hint: This question can be answered by trial-and-error; consult the on-line help for the necessary modification to the syntax of rightbox and rightsum.)

Solution

This solution requires the parts of the Application that directly relate to the computation of the quadratic section of the stress-strain curve.

```
> restart; with(student):
> pt3 := [ 0.032, 330 ]:
> pt4 := [ 0.053, 440 ]:
> pt5 := [ 0.074, 360 ]:
> QUAD := sigma = a*epsilon^2 + b*epsilon + c;
> EQ1 := evalf( subs( epsilon=pt3[1], sigma=pt3[2], QUAD ), 2 );
> EQ2 := evalf( subs( epsilon=pt4[1], sigma=pt4[2], QUAD ), 2 );
> EQ3 := evalf( subs( epsilon=pt5[1], sigma=pt5[2], QUAD ), 2 );
```

$$QUAD := \sigma = a\,\varepsilon^2 + b\,\varepsilon + c$$

$$EQ1 := 330. = .0010\,a + .032\,b + c$$

$$EQ2 := 440. = .0028\,a + .053\,b + c$$

$$EQ3 := 360. = .0055\,a + .074\,b + c$$

```
> SOLN2 := solve( { EQ1, EQ2, EQ3 }, { a, b, c } ):
> SOLN2 := evalf( SOLN2, 2 );
> stress := subs( SOLN2, rhs(QUAD) );
```

$$SOLN2 := \{ b = 23000.,\ a = \text{-}210000.,\ c = \text{-}210. \}$$

$$stress := -210000.\,\varepsilon^2 + 23000.\,\varepsilon - 210.$$

```
> tough[quad4R] := evalf( rightsum( stress, epsilon=0.032..0.074 ) );
```

$$tough_{quad4R} := 16.30718250$$

```
>
```

The plan is to double the number of rectangles until the first four digits of the approximations stabalize.

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 8 ) );
```

$$16.34714813$$

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 16 ) );
```

$$16.33674328$$

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 32 ) );
```

$$16.32394395$$

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 64 ) );
```

$$16.31564505$$

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 128 ) );
```

$$16.31102079$$

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 256 ) );
```

$$16.30858996$$

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 512 ) );
```

$$16.30734487$$

At this point it can now be said that the four-digit approximation to the area under the stress-strain curve for 0.032 <= ε <= 0.074 is 16.31. This estimate is obtained with 128 rectangles.

```
>
```

Problem 6

Repeat the previous problem with trapezoid and simpson. What do these results tell you about the approximation errors associated with the use of rectangles, trapezoids, and quadratics to approximate the area under the parabola?

Solution

This solution requires the parts of the Application that directly relate to the computation of the quadratic section of the stress-strain curve.

```
> restart; with(student):
> pt3 := [ 0.032, 330 ]:
> pt4 := [ 0.053, 440 ]:
> pt5 := [ 0.074, 360 ]:
> QUAD := sigma = a*epsilon^2 + b*epsilon + c;
> EQ1 := evalf( subs( epsilon=pt3[1], sigma=pt3[2], QUAD ), 2 );
> EQ2 := evalf( subs( epsilon=pt4[1], sigma=pt4[2], QUAD ), 2 );
> EQ3 := evalf( subs( epsilon=pt5[1], sigma=pt5[2], QUAD ), 2 );
```

$$QUAD := \sigma = a\,\varepsilon^2 + b\,\varepsilon + c$$

$$EQ1 := 330. = .0010\,a + .032\,b + c$$

$$EQ2 := 440. = .0028\,a + .053\,b + c$$

$$EQ3 := 360. = .0055\,a + .074\,b + c$$

```
> SOLN2 := solve( { EQ1, EQ2, EQ3 }, { a, b, c } ):
> SOLN2 := evalf( SOLN2, 2 );
> stress := subs( SOLN2, rhs(QUAD) );
```

$$SOLN2 := \{c = -210., b = 23000., a = -210000.\}$$

$$stress := -210000.\,\varepsilon^2 + 23000.\,\varepsilon - 210.$$

```
>
```

The doubling algorithm used in Problem 5 will be used here with trapezoid and simpson replacing rightsum. To begin the search for the four-digit approximation with trapezoid, recall the approximation obtained in the Application

```
> tough[quad4T] := evalf( trapezoid( stress, epsilon=0.032..0.074 ) );
```

$$tough_{quad4T} := 16.14401250$$

```
>
> evalf( trapezoid( stress, epsilon=0.032..0.074, 8 ) );
```

$$16.26556313$$

```
> evalf( trapezoid( stress, epsilon=0.032..0.074, 16 ) );
```

16.29595078

```
> evalf( trapezoid( stress, epsilon=0.032..0.074, 32 ) );
```

16.30354770

```
> evalf( trapezoid( stress, epsilon=0.032..0.074, 64 ) );
```

16.30544693

```
> evalf( trapezoid( stress, epsilon=0.032..0.074, 128 ) );
```

16.30592173

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 256 ) );
```

16.30858996

```
> evalf( rightsum( stress, epsilon=0.032..0.074, 512 ) );
```

16.30734487

As in Problem 5, the four-digit approximation to the area under the stress-strain curve for 0.032 <= ε <= 0.074 is 16.31. But, now this estimate is obtained with only 64 rectangles.

>

For Simpson's Rule we begin by recalling the estimate when four subintervals (two parabolas) are used to estimate the area

```
> tough[quad4S] := evalf( simpson( stress, epsilon=0.032..0.074 ) );
```

$tough_{quad4S} := 16.30608000$

>

As the number of subintervals is doubled:

```
> evalf( simpson( stress, epsilon=0.032..0.074, 8 ) );
```

16.30608000

```
> evalf( simpson( stress, epsilon=0.032..0.074, 16 ) );
```

16.30608001

These results do not change as the number of subintervals is increased (except possibly for the last digit - which is not significant). The reason for this is that the stress is a quadratic function and Simpson's Rule is exact for quadratic functions. The four-digit approximation agrees with our previous results, but is obtained with much less work (in fact, only 2 subintervals are needed).

```
> evalf( simpson( stress, epsilon=0.032..0.074, 2 ) );
```

16.30608000

>

While this is only one example, the fact that the different quadrature rules have different convergence rates. The convergence rate for Simpson's Rule, which uses quadratic approximations to the function, is faster than the Trapezoid Rule, which uses linear functions. And, the "Right-Hand" Rule, which uses constants to approximate the function, requires the most subintervals to obtain the same accuracy.

Problem 7

The integral of a nonnegative function is the limit of the area of rectangles. In the previous problems, you estimated the area under the quadratic curve to two digits of accuracy. Compute the exact area under the curve as an integral. First, use the online help to find the Maple command for computing definite integrals. How does this value compare to the approximation in this chapter and in Problem 6?

Correction

The previous problems estimated the area under the quadratic curve to four (not two) digits of accuracy. This does not change the current problem in any way.

Solution

This solution requires the parts of the Application that directly relate to the computation of the quadratic section of the stress-strain curve.

```
> restart; with(student):
> pt3 := [ 0.032, 330 ]:
> pt4 := [ 0.053, 440 ]:
> pt5 := [ 0.074, 360 ]:
```

```
> QUAD := sigma = a*epsilon^2 + b*epsilon + c;
> EQ1 := evalf( subs( epsilon=pt3[1], sigma=pt3[2], QUAD ), 2 );
> EQ2 := evalf( subs( epsilon=pt4[1], sigma=pt4[2], QUAD ), 2 );
> EQ3 := evalf( subs( epsilon=pt5[1], sigma=pt5[2], QUAD ), 2 );
```

$$QUAD := \sigma = a\,\varepsilon^2 + b\,\varepsilon + c$$

$$EQ1 := 330. = .0010\,a + .032\,b + c$$

$$EQ2 := 440. = .0028\,a + .053\,b + c$$

$$EQ3 := 360. = .0055\,a + .074\,b + c$$

```
> SOLN2 := solve( { EQ1, EQ2, EQ3 }, { a, b, c } ):
> SOLN2 := evalf( SOLN2, 2 );
> stress := subs( SOLN2, rhs(QUAD) );
```

$$SOLN2 := \{c = \text{-}210., b = 23000., a = \text{-}210000.\}$$

$$stress := -210000.\,\varepsilon^2 + 23000.\,\varepsilon - 210.$$

```
>
```

This problem can be solved using either int or Int. The advantage of using Int is that it gives the user a chance to check that the correct integral has been entered before the calculation is performed.

```
> tough[exact] := Int( stress, epsilon=0.032..0.074 );
```

$$tough_{exact} := \int_{.032}^{.074} -210000.\,\varepsilon^2 + 23000.\,\varepsilon - 210.\,d\varepsilon$$

```
> tough[exact] := evalf( tough[exact] );
```

$$tough_{exact} := 16.30608000$$

Note that this result is exactly the same as the result obtained by Simpson's Rule in Problem 6. This is further verification that Simpson's Rule is exact for this problem.

```
>
```

Problem 8

Investigate the usage of stats[fit] as a means of fitting the data to a quadratic function. Verify results in a worksheet. Then collect more data, and compute the revised fit and corresponding contribution to the modulus of toughness.

Investigate the benefits of collecting more data and using fit to obtain a better approximation to the Young's modulus.

Solution

There are many ways to approach this problem. For information on the fit command, see the section Least Squares Fit to Data (p. 105) in Chapter 4.

Problem 9

This chapter presented techniques for the insertion of new sections, execution groups, text regions, and other common elements of a Maple worksheet. Elements can also be removed from a worksheet. The only menu selection that relates to deletion is Delete Paragraph (under Edit). Use the on-line help to learn how to delete a section and execution group.

Solution

See the worksheet,howto help document. If you look at the Execution Group or Section section you will be referred to the Deleting section. These connections are made via bookmarks (which are not otherwise discussed in this module). For more information about bookmarks, see the Bookmarks section in the worksheet,howto help document.

Problem 10

Create documented worksheets, including hyperlinks to relevant help documents for the solution to Example1-1 and for the five-step problem-solving process used to analyze Application 1 in Chapter 1.

Solution

Solutions are similar to previously discussed sample worksheets. No detailed solution provided.

>