# Chapter 2 _____

# A Quick Introduction to MuPAD

Before ordering or downloading MuPAD, you should make sure that you have hardware good enough to run this program.

In order to run MuPAD on your computer, you need an IBM compatible PC (Pentium I or higher) with 32 MB of RAM, a CD-ROM drive, and about 40 MB of available disk space. Your system must be running Windows 95/98/ME/NT 4.0/2000 or the Linux operating system. However, 64 MB of RAM and a Pentium II with 400 MHZ processor are recommended. You may also run MuPAD on the Solaris operating system for SUN Sparc.

In order to take full advantage of the many resources provided by the MuPAD team, you may also need an Internet connection and access to e-mail.

The second thing you will need is of course the MuPAD program. MuPAD is distributed by SciFace – a software company in Germany. You can download a trial version of MuPAD which will work for one month, from their web site at `http://www.mupad.de`. On this same web site you will find information on how to order MuPAD, as well as information about the *Euclid* program. This program was developed for educators who want to test MuPAD in their classroom.

## 2.1 The Very First Look

In order to start MuPAD on Windows based system you need only to click on its icon from the Start menu. If you going to use it frequently it may be more convenient for you to place on the desktop of your computer a shortcut to MuPAD executable file. It may look like this:



Now you are ready to start MuPAD. Double click the icon on the

desktop and you will get MuPAD window on the screen of your computer. It may at first look similar to the one in the enclosed picture, but after a few days of using MuPAD you will certainly introduce some modifications.
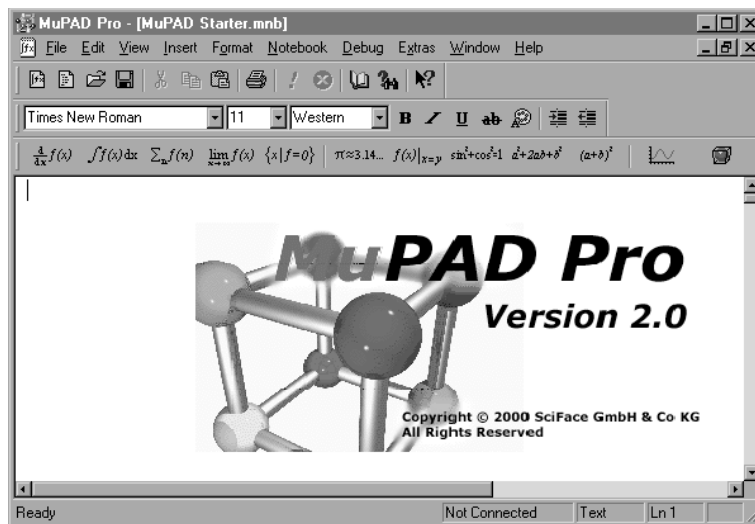


*Fig. 2.1 MuPAD Pro version 2 screen*

If this is your first contact with MuPAD you may want to read the document on the screen or just start your first MuPAD explorations. In order to start working with MuPAD choose the **File** menu and then the option **New Notebook,** or just press [Ctrl]+[N].

**CONVENTION:** Throughout this book I will frequently ask you to press a key or a combination of keys. It may look like this [Ctrl] or [Ctrl]+[N]. A single square bracket means that you have to press a single key with the given text or character; for example [Ctrl] means the Control key and [N] the key with letter "N". Two keys with plus between them will mean that you have to press these two keys at the same time. For instance [Ctrl]+[N] means press [Ctrl] key, and while holding it press [N] key. Combinations of keys like the above [Ctrl]+[N] are called key sequences and these are very useful shortcuts to many operations that are available through menus.

MuPAD is a command line program. Thus, in order to obtain any result from it you have to type in the appropriate command and press [Enter]. It may look like this:

• 1.78 + 1.2 /* now press [Enter] */

2.98

- 123 + 345

  468

The bullet on the left side means that you are ready to type in a command that shall be performed by MuPAD. We will call the space to the right of the bullet the input region. On a Mac or in Unix, instead of a bullet a different character will be used. Below the input region is the output region. Every time you press [Enter] MuPAD tries to evaluate your command and print obtained result. Usually, the text in the input region is red and the output text or formula is blue. However, for the purpose of this book I made both of them black—this will make the black-and-white printout more clear.

Observe, they key [Enter] in MuPAD is used to evaluate the input, while the key sequence [Shift]+[Enter] to break an input line. If you feel that this is not convenient, you may easily redefine it. I will show you later how to do this. Now let's practice some MuPAD commands to taste its flavor.

## 2.2  Getting Started

We shall start with something simple, but not trivial. Otherwise you would have a feeling that you are using a standard calculator. The first difference between a standard calculator and MuPAD is the possibility of typing in complicated formulae and getting the results at once. In a calculator the same operation may take many steps. For instance imagine that you going to calculate $(123.897 + 23.987)/(67.987 - 763.98)$. In a calculator you will have to first obtain $123.897 + 23.987$ then obtain $67.987 - 763.98$ and finally divide first obtained result by second. In MuPAD you can obtain the final result by a single command:

- (123.897 + 23.987)/(67.987 - 763.98)

  $-0.2124791485$

Now let's do something more difficult, for instance let's check how MuPAD calculates large integers. For this purpose, a factorial of a three or four digit integer will be ideal - say, 456!

- 456!

```
150777392777170659033285627982974829327648499663011\
315324902295697797980802999492049275470580840593582\
700556154654997912467653672836190567363944536581444\
396786039028419417159553169852939652733499484374432\
647121409002713034716885273557660568294514238651304\
204026421026217797122437474581042706674997505548774\
529387552185264469304745879944335896334980134727576\
771262477699704913814778801164976379963316514713032\
786305083016847394455111607701177156363125206697642\
497352441989049637406799105387152093299654856194446\
887474831405921359722324720996553956200165400519069\
670468845686118517860926559421327845227712982865242\
890852011587912148558934925229259778865164753102371\
910801614732061965104129730561590839408147446252948\
841011789641706225763887234100676084552005497753764\
496546383864694159909979495432469993306110242973486\
330432796522331628915418533758582252153753291412897\
349335363154308911927972242304805109760000000000000\
000000000000000000000000000000000000000000000000000\
000000000000000000000000000000000000000000000000
```

Well, you perhaps started wondering how far you can go with large numbers in MuPAD. The best response is—just try. Calculate a few more examples like the above and see what you can get. For example how much will be 9999! and how much time it will take to calculate it. Depending on how powerful is your computer it may take a few seconds to a few minutes to obtain a very impressive result—a few pages of digits ended by about 40 lines of zeros. It seems that we've got quite an interesting toy.

Let's try something different. For example let's try to solve a few equations.

- `solve(x^2 - 2*x - 5 = 0, x)`

$$\left\{ \sqrt{6} + 1, -\sqrt{6} + 1 \right\}$$

- `solve(x^2 + 1 = x^4, x)`

$$\left\{ -\frac{\sqrt{2}\cdot\sqrt{\sqrt{5}+1}}{2}, \frac{\sqrt{2}\cdot\sqrt{\sqrt{5}+1}}{2}, -\frac{\sqrt{2}\cdot\sqrt{-\sqrt{5}+1}}{2}, \frac{\sqrt{2}\cdot\sqrt{-\sqrt{5}+1}}{2} \right\}$$

Both equations are very simple but imagine that you have to solve the second equation by hand. It could take some time before you will be able to write the final solution.

You have seen that MuPAD quite easily solves equations. How about inequalities. These are usually painful problems for our students.

- `solve(x^3 - 2*x^5 + x > 0, x)`

  $]0,1[ \cup ]-\infty,-1[$

In our solution we got two open intervals: $]-\infty,-1[$ and $]0,1[$ which is quite obvious if you try to plot the above inequality.
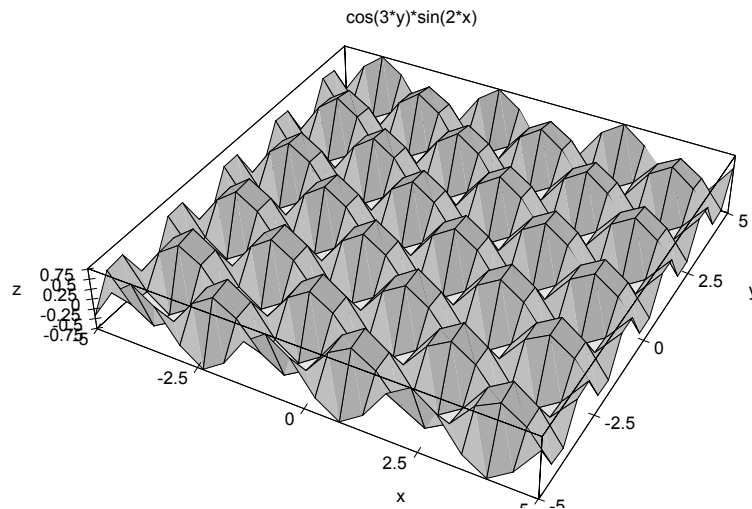
While working with mathematics we use a lot of plots. Let's try to do a few plots with MuPAD. First we start with a very basic plot of the function $y = \sin 2x \cos 3x$.

- `plotfunc2d(sin(2*x)*cos(3*x))`
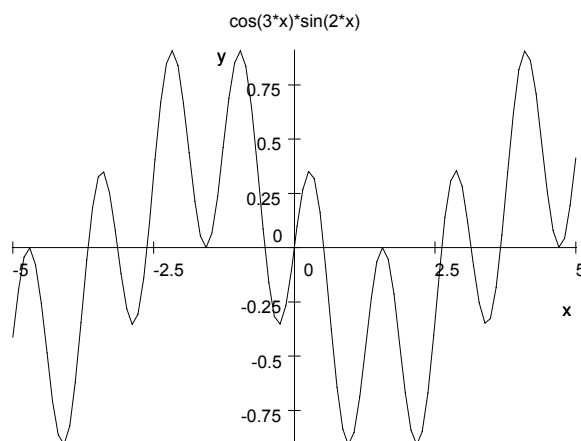


The obtained picture looks very interesting, but what about 3D plots? Let's try a similar function but in 3D. Let $z = \sin 2x \cos 3y$.

- `plotfunc3d(sin(2*x) * cos(3*y))`

cos(3*y)*sin(2*x)

The obtained graph was plotted with MuPAD default parameters, but of course we can make it more accurate and choose only the part which we need. We will come to MuPAD plots later.

You perhaps noticed that up to now all the operations were done in the mode that is similar to the way how calculator works – type in a single command and press [Enter]. However, in MuPAD you can go much further. You can write programs like in many programming languages. MuPAD programs are similar to Pascal programs. For instance, can you recognize what the program given below is doing?

```
n := 10:
MyFact := 1:
for i from 1 to n do
  MyFact := MyFact*i
end
3628800
```

Well, it was easy to guess that this program calculates the product of integers between 1 and 10. This means we shall get 10!. Let's try to check it in MuPAD:

```
10!
```

3628 800

You have already learned a few interesting features of MuPAD and now it is time to explore its interface.

## 2.3  A Quick Look at MuPAD's Interface

You have already seen the MuPAD interface on your computer screen or in the picture enclosed on the beginning of this chapter. It doesn't look very complicated and it certainly reminds you of many other programs for MS Windows. You can easily identify the menu at the top of the window and three toolbars: standard toolbar, format toolbar and command bar.

Most of the menu options are similar to what you know from MS Word and other programs for Windows. However, there are a few things that are different and that are worth checking.

Using options from **File** menu you can open a new notebook – this is what you will be doing frequently; save and print notebook. Do not miss the option **Export**, where you can export your MuPAD notebook as an RTF document or TXT file. Saving notebook as TXT is not too much of use for us as we will lose all the formatting. However, when you export your notebook as RTF document, you will be able to open this document in any word processing program and all the formatting will remain. Which means that the fonts, colors and pictures will be like you had it in original MuPAD notebook.

The **Edit** menu looks exactly the same like in other Windows programs, so you do not need to bother about this now.

Some of the operations from **File** menu and **Edit** menu are available also from the standard toolbar:



*Fig. 2.2 Standard toolbar in MuPAD*

Using the **View** menu you can display or remove toolbars from the screen. The most important for you may be the **Options** menu (Fig.

2.3.) . Let's take a look at it. You will find a few things there that you may need in the future. Here you can change MuPAD's default behavior for the key [Enter] in the input regions. Just choose in **Evaluate On** option **Shift+Enter** or **Enter only**.
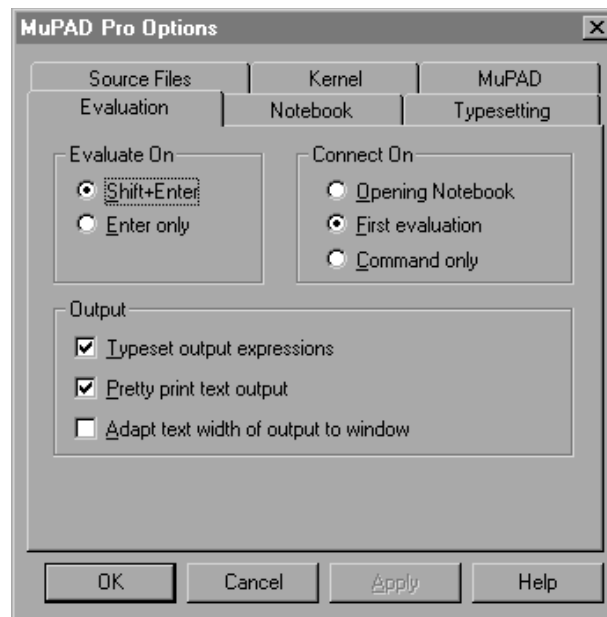


*Fig. 2.3 MuPAD Pro options*

The most important for the rest of this chapter will be **Output** options. If you wish to have nicely formatted text and formulae on the screen and on the printout you should check the two check boxes: **Typeset..** and **Pretty print..** .

The **Insert** and **Format** menus you will use later while editing MuPAD notebooks. In the **Notebook** menu, is a very useful option - **Evaluate**. You can evaluate a single MuPAD input region and this works the same way like [Enter], except that you can evaluate the whole notebook from the beginning. This can be quite useful while working on large projects or a simulation. For example, you can place in the beginning of the notebook all declarations and evaluate notebook to get final result; then, later, you may change these declarations and evaluate the notebook again to get the results for the new declarations, and again and again.

The **Debug** menu will be useful in more advanced applications and you may leave it for your later investigations. Finally, very useful is the menu **Extras**. This is the place where you should look for shortcuts to MuPAD operations. For example, if you do not remember a MuPAD command or you do not wish to type long commands you can choose them from this menu. Let's try to use **Extras** to draw a 3D plot. Just find the option: **Plot 3D function**. You shall obtain on the screen:

- `plotfunc3d(%?)`

Now replace %? by the equation of your function and press [Enter], for instance:

- `plotfunc3d(3*sin(x)*cos(y))`
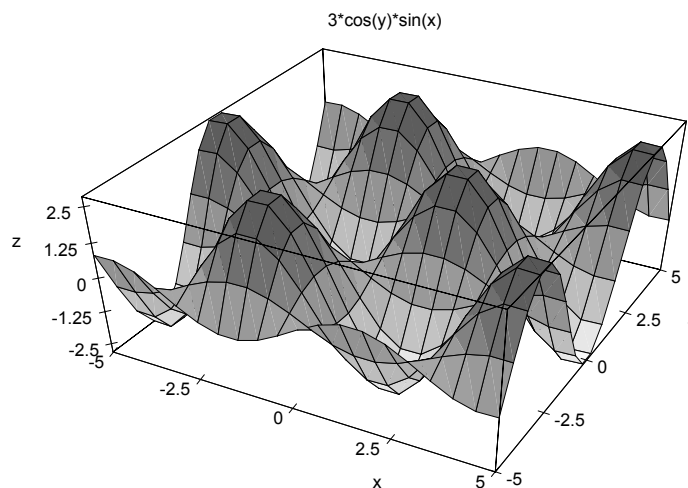


This is the easiest way to perform some less complicated MuPAD operations. However, you should remember that the collection of MuPAD commands and their parameters is so large that there is no way to put them all in a menu like this.

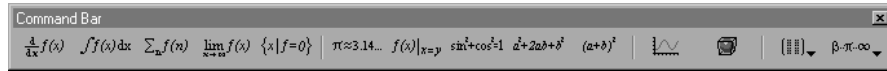Some of the most frequently used MuPAD operations are also available from Command bar:

*Fig. 2.4 MuPAD's command bar*

There is another way to get a quick access to MuPAD operations. Let's try it. Suppose you wish to plot a graph of a function. In any input region type **pl** (this is usually the beginning of names of many plotting operations) and press [Ctrl]+[Shift]. You shall get a pop-up helper box with names of all MuPAD operations that start with "pl". It may look like this in the enclosed picture.



*Fig. 2.5 MuPAD helper box*

Now, you shall click the name of the operation you need and add appropriate parameters. If many cases MuPAD will complete the name of the command automatically.

## 2.4  Formatting Documents in MuPAD

We are used to working with nice documents where multiple fonts, styles and colors are applied. The editing functions in MuPAD are a bit limited but we should still remember that MuPAD is not a word processing program nor a typesetting tool. However, you have here enough of tools to make your notebook look nice.

You know already that in MuPAD there are two kinds of regions: input and output region. Now is the time to find out that you may have a third region for text. Thus, in one document you can mix text
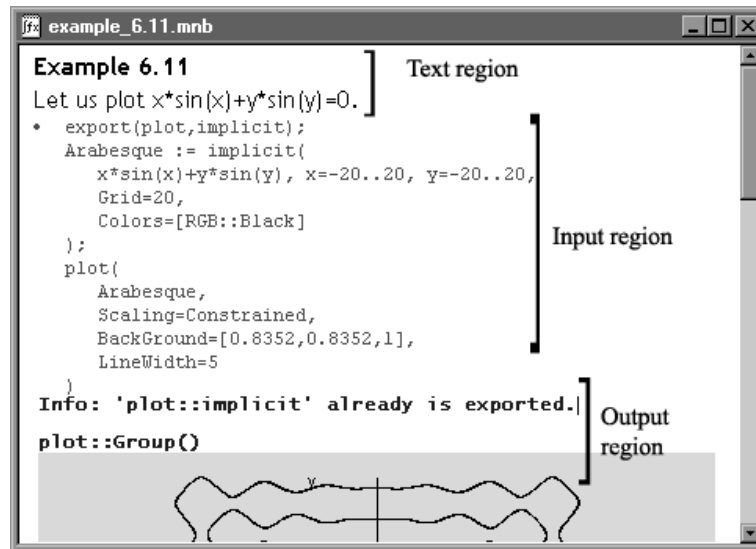
and calculations.



*Fig. 2.6 MuPAD screen with text, input and output regions*

Usually, MuPAD starts a new notebook with one input region on top of the screen. In order to insert a text area above or below this region choose from **Insert** menu option **Text above** or **Text below**. These two operations are available through key sequences [Ctrl]+[F6] and [F6]. Now choose in the formatting toolbar an appropriate font, its size, color and other parameters. The picture below shows what the formatting toolbar offers.



*Fig. 2.7 MuPAD's formatting toolbar*

You can change appearance of existing text by selecting it and then, while selected, choosing from formatting toolbar appropriate parameters.

There is a way to define editing parameters for the whole document. For example you may wish to have all input commands in Letter Gothic font, 10 points and in black. Or all output text in italics. In

order to do this choose in **Format** menu option **Fonts**. You will get the **Font** dialog box, where you can define all font settings (see Fig. 2.8). Here you can choose your favorite font, color, size and attributes for it and then apply these font settings to any region, text, input or output region in your notebook (see Fig. 2.6). Do not forget to check the option **Apply to whole document**. Changes done here will not affect formulae in the output region. However, you can change them also by going to the **Expressions** option from the **Format** menu.
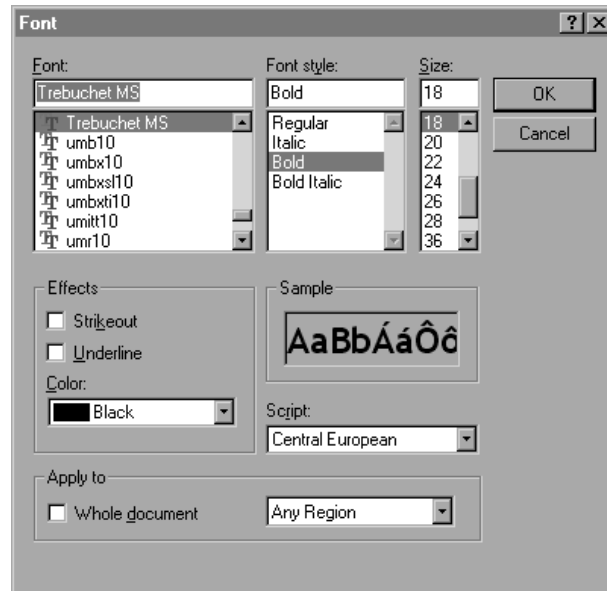


*Fig. 2.8  Font setting dialog box*

MuPAD doesn't allow us to delete or edit an output region. In order to remove it or edit it, you must first change it to a text or input region by using the menu **Notebook** and then apply an appropriate change.

In order to insert an input region above or below the current cursor position choose from the **Insert** menu the option **Input above** or **Input below**. These two operations are available through key sequences [Ctrl]+[F5] and [F5].

## 2.5  Getting Help

While working with MuPAD, sometimes you may feel a bit lost. It

happens that you do not remember a syntax of the command or exact name of the command. In such case it is worth to check MuPAD about the problematic issue. For instance let's see what MuPAD can tell us about the object **student**. You can ask about this in a few ways—by issuing the commands **info**, **help** or just **?student**. Here is how each of them works.

Command `info(student)` produces the following output:

* ```
  info(student)
  Library 'student': the student package
  -- Interface:
  student::Kn,          student::equateMatrix,
  student::isFree,      student::plotRiemann,
  student::plotSimpson, student::plotTrapezoid,
  student::riemann,     student::simpson,
  student::trapezoid
  ```

While commands:

* `help("student")`
* `?student`

Will display MuPAD help browser box like this on Fig. 2.9.

By clicking on [**Display**] button you are going to get very detailed hypertext help pages with a number of examples showing how the command can be applied. Each term with yellow background is linked to a page with further explanations. For example, by clicking on the word `examples` with a yellow background you will go to a page with examples showing how to use the given command. You can copy each example to your notebook by clicking arrows >> with green background in front of the example.
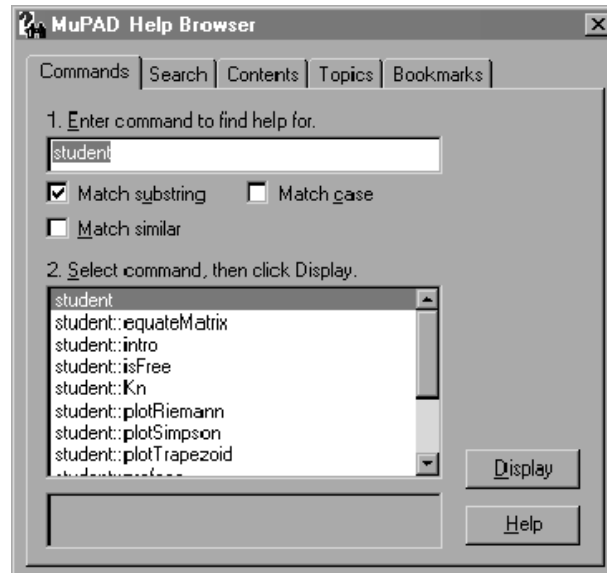
*Fig. 2.9 MuPAD help browser*
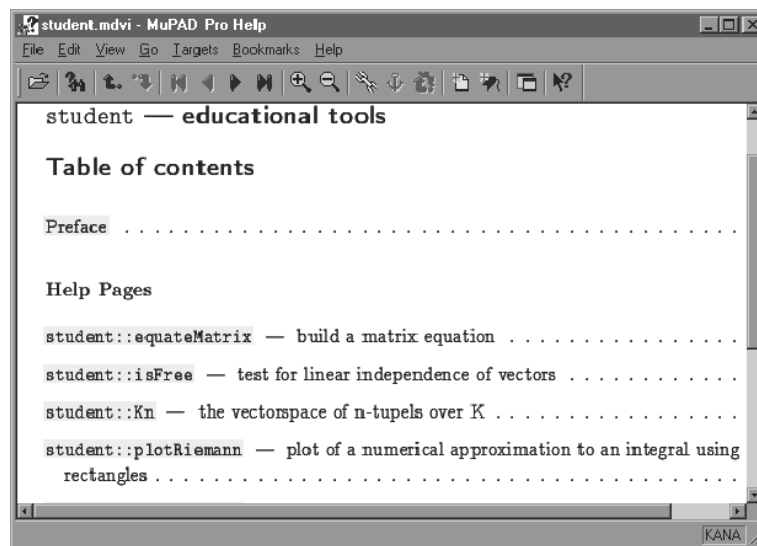


*Fig 2.10 Help page for the student library*

The MuPAD help browser can be useful for learning about MuPAD

features. You can search for a given word which is not necessarily a MuPAD command, you can browse the MuPAD manual, tutorial and other files included with your copy of the program.

MuPAD help files cannot be printed; however, if you are connected to the Internet you can always access the online help and print the pages that you are interested in.

## 2.6  Chapter Summary

Before we proceed to the next chapter, let's take a look at what we have learned in this chapter.

We got accustomed to the MuPAD interface and the notebook's structure. We had also learnt a few MuPAD shortcuts and instructions. Here are all of them.

### 2.6.1  MuPAD Shortcuts

[Ctrl]+[N] - *open a new notebook*

[Enter] (*in the input region*) - *execute the command*

[Ctrl]+[F6] - *insert text region above current line*

[F6] - *insert text region below current line*

[Ctrl]+[F5] - *insert input region above current line*

[F5] - *insert input region below current line*

[Ctrl]+[Shift] - *complete a MuPAD name*

### 2.6.2  MuPAD Instructions

n! - *produce factorial of integer n*

**solve**(*equation*) - *solve an equation with one variable*

**plotfunc2d**(*function*) - *plot a graph of a function of one variable*

**plotfunc3d**(*function*) - *plot a graph of a function of two variables*

**info**(*command*) - *display basic information for given command*

**help**("*command*") - *display help pages for the given command*

**?***command* - *display help pages for the given command*

Note that the **help** command requires that its parameter be given with double quotes (i.e. as a string).

## 2.7 Review Exercises

1. Open a new MuPAD notebook and save it as `review_01.mnb`. Above the existing input region insert a text area. Place the cursor at the beginning of the text line and use the formatting toolbar to change the font settings to Arial, 18 points, Bold, color Maroon. Now type there `Review exercises, set 1.` This is the title of your notebook. Below the title insert a new line for text (just press [Enter]) and change its font settings to Times New Roman, italic, 16 points, color Navy. In this line type `Calculations in MuPAD`. This will be the title of the first computing section.

2. Place the cursor beam at the beginning of the input region below the section title and type in the command to calculate (234/345) + (34/789). Press [Shift]+[Enter] to obtain result. In the same way, calculate 3455899999/234567, 33!, 333! and 3333!

3. Below the last output, create a new text area and change its font to Times New Roman, italic, 16 points, color Navy. In this line type `MuPAD 2D plots`. This will be the next section of your notebook. Below it, insert a new input region.

4. In the last input region type command to plot function $y = \sin(5x) + \cos(3x)$ and obtain its plot. In the same way, obtain plots of functions $y = (1/x)\sin x$, $y = \sin(1/x)$, $y = x\sin(1/x)$. Each command should be typed in as a separate input. You shall obtain four separate plots.

5. Now it's time to practice 3D plots. Below the last picture insert a new line for text and again set its font to Times New Roman, italic, 16 points, color Navy. In this line, type `MuPAD 3D plots` and insert a new input region below.

6. Type in the commands to plot 3D plots of functions: $y = (1/x)\sin x\cos y$, $y = \sin(1/(xy))$, $y = (xy)\sin(1/(xy))$. Again, you shall type in each command in a separate input region and you shall get three separate plots.

7. At the end of your review notebook insert a new section entitled `MuPAD help`. Like other headers before, set it in the Times New

Roman font, italic, 16 points, color Navy.

8. Below the last header insert a new input region. Type here in and then press [Ctrl]+[Shift]. From the pop-up helper box choose the info command. Now use the `info` command to get information about `plot` and `solve`. Use `help` and `?solve` to get more information about `solve` command. Reminder: `help(solve)` will not work, you shall have to use `help("solve")`.

9. Finally, go to the **Notebook** menu and click on **Delete Output**. This will remove all outputs from your notebook. Now calculate all commands in your notebook again – you shall go to the **Notebook** menu and choose there **Evaluate** and then **Any Input**.

10. Save your notebook.