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1.2 Simple Examples

The following chapters describe all of Octave's features in detail, but before doing that, it might be helpful to give a sampling of some of its capabilities.

If you are new to Octave, we recommend that you try these examples to begin learning Octave by using it. Lines marked like so, '*octave:13>*', are lines you type, ending each with a carriage return. Octave will respond with an answer, or by displaying a graph.

1.2.1 Elementary Calculations

Octave can easily be used for basic numerical calculations. Octave knows about arithmetic operations (+,-,*,/), exponentiation (^), natural logarithms/exponents (log, exp), and the trigonometric functions (sin, cos, …). Moreover, Octave calculations work on real or imaginary numbers (i,j). In addition, some mathematical constants such as the base of the natural logarithm (e) and the ratio of a circle's circumference to its diameter (pi) are pre-defined.

For example, to verify Euler's Identity,

$$e^{i\pi} = -1$$

type the following which will evaluate to *−1* within the tolerance of the calculation.

```
octave:1> exp (i*pi)
```

1.2.2 Creating a Matrix

Vectors and matrices are the basic building blocks for numerical analysis. To create a new matrix and store it in a variable so that you can refer to it later, type the command

```
octave:1> A = [ 1, 1, 2; 3, 5, 8; 13, 21, 34 ]
```

Octave will respond by printing the matrix in neatly aligned columns. Octave uses a comma or space to separate entries in a row, and a semicolon or carriage return to separate one row from the next. Ending a command with a semicolon tells Octave not to print the result of the command. For example,

```
octave:2> B = rand (3, 2);
```

will create a 3 row, 2 column matrix with each element set to a random value between zero and one.

To display the value of a variable, simply type the name of the variable at the prompt. For example, to display the value stored in the matrix *B*, type the command

```
octave:3> B
```

1.2.3 Matrix Arithmetic

Octave has a convenient operator notation for performing matrix arithmetic. For example, to multiply the matrix *A* by a scalar value, type the command

```
octave:4> 2 * A
```

To multiply the two matrices *A* and *B*, type the command

```
octave:5> A * B
```

and to form the matrix product *transpose (A) * A*, type the command

```
octave:6> A' * A
```

1.2.4 Solving Systems of Linear Equations

Systems of linear equations are ubiquitous in numerical analysis. To solve the set of linear equations *Ax = b*, use the left division operator, '\':

```
x = A \ b
```

This is conceptually equivalent to *inv (A) * b*, but avoids computing the inverse of a matrix directly.

If the coefficient matrix is singular, Octave will print a warning message and compute a minimum norm solution.

A simple example comes from chemistry and the need to obtain balanced chemical equations. Consider the burning of hydrogen and oxygen to produce water.

```
H2 + O2 --> H2O
```

The equation above is not accurate. The Law of Conservation of Mass requires that the number of molecules of each type balance on the left- and right-hand sides of the equation. Writing the variable overall reaction with individual equations for hydrogen and oxygen one finds:

```
x1*H2 + x2*O2 --> H2O
H: 2*x1 + 0*x2 --> 2
```

```
O: 0*x1 + 2*x2 --> 1
```

The solution in Octave is found in just three steps.

```
octave:1> A = [ 2, 0; 0, 2 ];
octave:2> b = [ 2; 1 ];
octave:3> x = A \ b
```

1.2.5 Integrating Differential Equations

Octave has built-in functions for solving nonlinear differential equations of the form

```
dx
-- = f (x, t)
dt
```

with the initial condition

```
x(t = t0) = x0
```

For Octave to integrate equations of this form, you must first provide a definition of the function *f(x,t)*. This is straightforward, and may be accomplished by entering the function body directly on the command line. For example, the following commands define the right-hand side function for an interesting pair of nonlinear differential equations. Note that while you are entering a function, Octave responds with a different prompt, to indicate that it is waiting for you to complete your input.

```
octave:1> function xdot = f (x, t)
>
>  r = 0.25;
>  k = 1.4;
>  a = 1.5;
>  b = 0.16;
>  c = 0.9;
>  d = 0.8;
>
>  xdot(1) = r*x(1)*(1 - x(1)/k) - a*x(1)*x(2)/(1 + b*x(1));
>  xdot(2) = c*a*x(1)*x(2)/(1 + b*x(1)) - d*x(2);
>
> endfunction
```

Given the initial condition

```
octave:2> x0 = [1; 2];
```

and the set of output times as a column vector (note that the first output time corresponds to the initial

condition given above)

```
octave:3> t = linspace (0, 50, 200)';
```

it is easy to integrate the set of differential equations:

```
octave:4> x = lsode ("f", x0, t);
```

The function *lsode* uses the Livermore Solver for Ordinary Differential Equations, described in A. C. Hindmarsh, *ODEPACK, a Systematized Collection of ODE Solvers*, in: Scientific Computing, R. S. Stepleman et al. (Eds.), North-Holland, Amsterdam, 1983, pages 55–64.

1.2.6 Producing Graphical Output

To display the solution of the previous example graphically, use the command

```
octave:1> plot (t, x)
```

If you are using a graphical user interface, Octave will automatically create a separate window to display the plot.

To save a plot once it has been displayed on the screen, use the print command. For example,

```
print -dpdf foo.pdf
```

will create a file called *foo.pdf* that contains a rendering of the current plot in Portable Document Format. The command

```
help print
```

explains more options for the *print* command and provides a list of additional output file formats.

1.2.7 Editing What You Have Typed

At the Octave prompt, you can recall, edit, and reissue previous commands using Emacs- or vi-style editing commands. The default keybindings use Emacs-style commands. For example, to recall the previous command, press *Control-p* (written *C-p* for short). Doing this will normally bring back the previous line of input. *C-n* will bring up the next line of input, *C-b* will move the cursor backward on the line, *C-f* will move the cursor forward on the line, etc.

A complete description of the command line editing capability is given in this manual, see Command Line Editing.

1.2.8 Help and Documentation

Octave has an extensive help facility. The same documentation that is available in printed form is also available from the Octave prompt, because both forms of the documentation are created from the same input file.

In order to get good help you first need to know the name of the command that you want to use. The name of this function may not always be obvious, but a good place to start is to type `help --list`. This will show you all the operators, keywords, built-in functions, and loadable functions available in the current session of Octave. An alternative is to search the documentation using the `lookfor` function (described in Getting Help).

Once you know the name of the function you wish to use, you can get more help on the function by simply including the name as an argument to help. For example,

```
help plot
```

will display the help text for the `plot` function.

Octave sends output that is too long to fit on one screen through a pager like `less` or `more`. Type a `RET` to advance one line, a `SPC` to advance one page, and `q` to quit the pager.

The part of Octave's help facility that allows you to read the complete text of the printed manual from within Octave normally uses a separate program called Info. When you invoke Info you will be put into a menu driven program that contains the entire Octave manual. Help for using Info is provided in this manual, see Getting Help.

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