A Brief Introduction To

GRTensor

On MAPLE Platform

A write-up for the presentation delivered on the same topic as a part of the course PHYS 601

March 2012

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A brief introduction to MAPLE

MAPLE is an analytical computation package and was developed first in 1980 by the Symbolic Computational Group, at the University of Waterloo, Ontario, Canada. Since 1988, it has been developed and distributed commercially by MAPLESOFT INC. There have been 15 major versions till now, with most of these versions having subversions as well.

MAPLE has a small kernel written in C which is not very demanding in terms of the system resources.

The GUI of MAPLE is similar to that of any other computation package. It has the usual workspace, toolbars, status bars, menu bars and shortcut menus. Most commonly used operations can be accessed using these bars and menus. (Refer to slide 3)

The workspace of MAPLE can be used both as a text editor and as a place to do the mathematical computation. One can toggle between the two modes using the ‘Math’ and ‘Text’ icons on the context bar. Some other word processing options are also made available on the context menu.

Before going further with the available features and commands, it must be stressed that **MAPLE is an analytical computational package** and hence can deal with as yet numerically undefined constants.

Once familiar with the syntax used, one can easily perform mathematical operations and add text, all of which is appears in the active worksheet, which can be saved as a ‘.mw’ file.

MAPLE shows the fed mathematical notations just as we write them on paper (refer to slide 4), which makes it convenient to review the data and make corrections if any.

MAPLE can be used to perform a wide range of mathematical operations: simple arithmetic, calculus, differential equations, matrixes, finding roots of functions etc.

Also contained in Maple library are a number of inbuilt algorithms of methods one commonly uses in computation. Hence once a differential equation is successfully fed, one can use a wide range of methods to solve it, both numerically and analytically. Slide 5 shows how one can solve a given differential equation by the common analytical method, Laplace method or obtain a series solution.

Slide 6 shows how one can use MAPLE to find points of intersection of two functions, if they exist, and to solve arithmetic equations. Note that in the example cited, coefficients of the linear equations were not explicitly defined, undefined constants so to say. Hence we get the result in terms of these constants.

MAPLE can also be used for plotting purposes. One can plot both 2-D as well as 3-D plots. Multiple curves may be plotted simultaneously in both 2-D and 3-D case. A number of formatting options are available for the plots: colour, axes, grids, legends, plot type etc. 3-D plots can be rotated around by simple click-drag of the mouse to give a complete 360^0 view of the curve. Slides 4, 7 and 8 depict just some of the operations one can do with plots.

Advantages of MAPLE

Following are some advantages I feel one has while using MAPLE:

- As mentioned earlier, MAPLE runs on a small kernel and is hence less demanding of resources. One can easily run MAPLE on machines with relatively 'inferior' system specifications.
- MAPLE is a numerical computation package. So not only can it deal with undefined constants (which are generally what people working in Sciences deal with) it also gives you an added advantage of attacking a problem using a mix of numerical and analytical techniques. Hence where mere numerical package may run out of ways to solve a given problem, such a hybrid package offers you more options.
- Certain packages, like GRTensor, are designed for running on a MAPLE platform.
- Costs significantly less compared to other some other packages which perform similar operations.

An Introduction to GRTensor

Working with tensors could be a messy affair, especially if there are a large number of components associated with the tensor. And then one most often requires much more out of these tensors than to just find their components. In light of this, a computation package that can deal with tensors and the related mathematics is god sent, especially for professionals working in fields of cosmology and astrophysics.

GRTensor is one such package which can deal with tensors and related manipulations. It was developed my Queen's University, Canada, which also distributes the package online.

Availability

GRTensor is a completely free package which was originally designed to run on MAPLE platform, but now a version compatible with MATHEMATICA is also available. One can download the package, installation instructions and related literature from http://grtensor.phy.queensu.ca/ . Also, separate versions are available for Windows, Linux or Mac OS.

Getting Started

Once installed and running, user can initiate the package by set of commands which reads the GRTensor Library into MAPLE Library (Refer to slide 11). The package has a number of predefined metric tensors which the user may load as per the need (Slide 11). Also one can define new metrics, use them temporarily or save them permanently to the Library (slide 15). Inputting new metrics can be initiated by the command 'makeg( )' and following onscreen instructions. One has the options of defining the metric in a matrix form, as a line element, as tetrads etc. depending upon the problem at hand.

Obtaining Tensors

Once a metric is chosen, the user may define his/her custom tensors using the specified commands. Also inbuilt are algorithms to access some very commonly used tensors computed from the metric in use, examples of some of which are presented in slides (11 – 14). Explicit commands are used to compute a quantity and to display the computed quantity. User can compute contravariant, covariant or mixed tensors, as need may be, using specified notations in the syntax for output. Also the time taken to compute the quantities, quantities computed as input for final result etc are displayed by default.

Tensor Manipulations

Almost all mathematical operation that one may require to do on tensors can be done using GRTensor. In slide 16, I give a brief overview of some of the commonly used operations when dealing with tensors and syntaxes for achieving these operations using GRTensor. Manuals on different functionalities of GRTensor are available at the official website mentioned above which address issues including installation, manipulations, defining new tensors, tensor algebra, tensor calculus etc.

Usefulness of the package??

As mentioned above, dealing with tensors may be a tedious job. The job may be manageable while dealing with tensors defined in Minkowski spacetime (which actually is the case for most branches of mathematics and physics) but one encounters notorious spacetimes in fields of cosmology and astrophysics. Computation of basic tensors from these metrics in such cases is usually so difficult that often people give up on the problem. Having a utility which can do this brute force mathematics for you is a great boon and one can thus devote his/her faculties towards unraveling the underlying physics, at least in principle!!