41a Computer Facilitated Teaching of Classical Mathematical Methods – Perturbation Techniques

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Recent advent of high-performance computers, high-efficient numerical schemes and user-friendly soft wares has helped instructors teach numerical solution and analysis of various nonlinear models effectively and efficiently in the class. One of the main objectives of a model is to provide the insight about the system of interest. Analytical solutions are the best possible solution for any model because they provide the best possible physical insight, as they are explicit in the system parameters. Having taught/co-taught applied math for both senior undergraduate and first-year graduate students for five years, the author feels that students do not appreciate the value of analytical solutions because (i) they wrongly feel that numerical methods can be used to solve complex problems using high-speed computers (ii) they are not comfortable and confident of doing the complicated integrals, rigorous algebra, transformations involved in obtaining analytical solutions. The author believes that various classical techniques to obtain analytical solutions can be taught efficiently using computers. For example, the computer algebra system like Maple, Mathematica, MATLAB, REDUCE etc. can be used to perform the tedious algebra, manipulations, complicated integrals, variable transformations, differentiations etc. involved in applying various mathematical methods. In this paper, we show how Maple can be used to facilitate perturbation technique for solving chemical engineering problems.

Perturbation is a powerful technique for obtaining closed-form and approximate solutions for both linear and nonlinear boundary value problems. The main difficulty in teaching perturbation techniques using a classical approach is that the students end up spending a lot of time for doing the algebraic manipulations involved in the perturbation techniques. In this paper, we show how perturbation technique can be efficiently taught using computers. For example, the program written and understood by the students for one example (diffusion with a first-order isothermal reaction in a rectangular catalyst pellet) can be used to solve complicated problems (non-isothermal reaction in a catalyst pellet) by only modifying only one line in the program for the governing equation. The author will run some simulation codes (written in Maple) using his laptop during the talk to the utility of such an approach. Mathematical methods like Separations of Variables technique, Similarity Solution Technique, Laplace transform technique, Perturbation technique, Conformal Mapping, Green's function technique, Analytical Method of Lines, Series solutions for nonlinear problems (multiple steady states) etc. can be facilitated using Maple. Some of these methods are illustrated in a text book to be published.1

References 1. R. E. White and V. R. Subramanian, Computational Methods in Chemical Engineering with Maple Applications, Springer-Verlag (to appear in 2005).