GEOMETRIC MULTIGRID FOR A JACOBIAN-FREE NEWTON KRYLOV SOLVER

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Abstract. The objective of this term project was to evaluate a Jacobian-Free Newton-Krylov (JFNK) method with multi-grid preconditioning.

1. Introduction. Hmmmmmmmm

1.1. Hmmmm.

2. 2D LRA Benchmark Problem. I applied my iterative solvers to the 2D LRA neutron diffusion problem. This benchmark problem requires solving for the neutron flux distribution within a simplified quarter-core of a typical pressurized light water nuclear reactor. The materials in the core are considered to be homogeneous in 15 cm $\times$ 15 cm cells as described in Figure 2 below. The nuclear data used for this simple benchmark problem - including absorption, fission, and scattering cross-sections - are condensed from continuous data by a 2-group energy approximation. The neutron diffusion equation is solved for the flux distribution for each energy group.

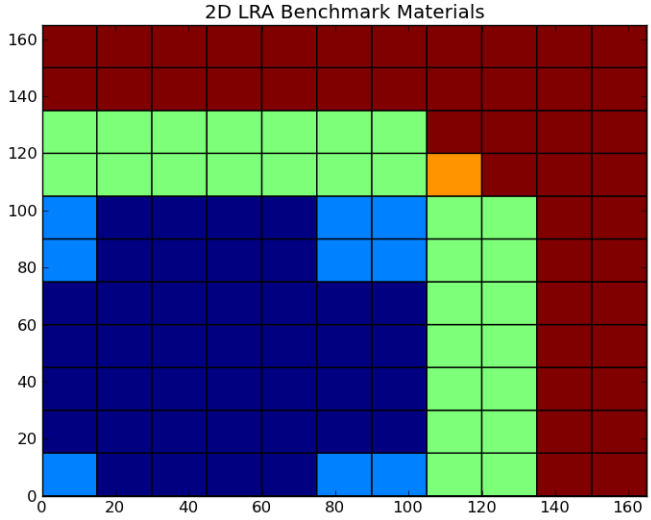

FIG. 2.1. *The coarse mesh materials design for the 2D LRA benchmark problem. Different enrichments of UO2 fuel are designated by dark/light blue, green and orange. Red represents a water reflector region.*

3. Jacobian-Free Newton Krylov.

4. Geometric Multi-Grid.

5. Methodology.

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6. Results.

```
\begin{subequations}\label{EKx}
\begin{equation}
 y_k =  B  y_{k-1} +  f, \qquad k=1,2,3,\ldots
\end{equation}
for  any initial vector $ y_0$.   Then
\begin{equation}
 y_k\rightarrow  u \mbox{\quad iff\quad} \rho( B)<1.
\end{equation}
\end{subequations}
```

7. Bibliography and BibTEX. If using BIBTEX, authors need not submit the `.bib` file for their papers. Merely submit the completed `.bbl` file, having used `siam.bst` as their bibliographic style file. `siam.bst` only works with BibTEX version 99i and later. The use of BibTEX and the preparation of a `.bib` file is described in greater detail in [3].

If not using BibTEX, SIAM bibliographic references follow the format of the following examples:

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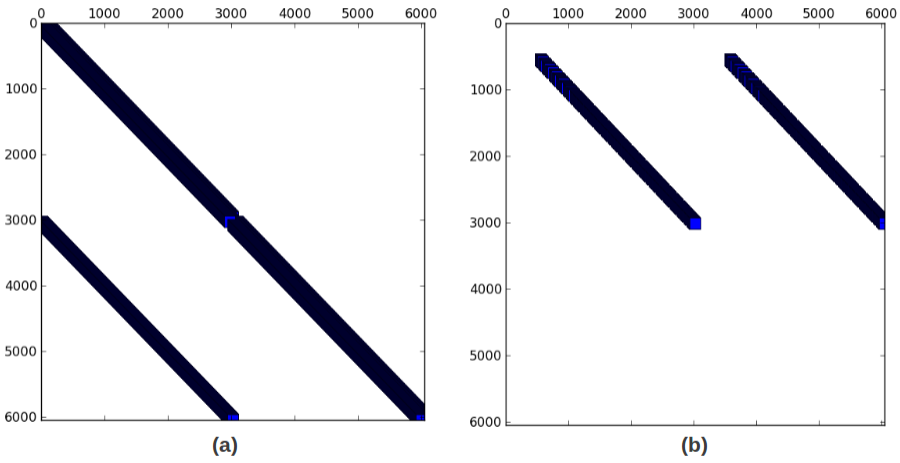
\bibitem{Ri} {\sc W. Riter},
```



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{\em Title of a paper appearing in a book}, in The Book
Title, E.~D. One, E.~D. Two, and A.~N. Othereditor, eds.,
Publisher, Location, 1992, pp.~000--000.

\bibitem{AuTh1} {\sc A.~U. Thorone}, {\em Title of paper
with lower case letters}, SIAM J. Abbrev. Correctly, 2
(1992), pp.~000--000.

\bibitem{A1A2} {\sc A.~U. Thorone and A.~U. Thortwo}, {\em
Title of paper appearing in book}, in Book Title: With All
Initial Caps, Publisher, Location, 1992.

\bibitem{A1A22} \sameauthor, % generates the 3 em rule
{\em Title of Book{\rm :} Note Initial Caps and {\rm ROMAN
TYPE} for Punctuation and Acronyms}, Publisher,
Location, pp.~000--000, 1992.

\bibitem{AuTh3} {\sc A.~U. Thorthree}, {\em Title of paper
that's not published yet}, SIAM. J. Abbrev. Correctly, to appear.
```

Other types of references fall into the same general pattern. See the sample file or any SIAM journal for other examples. Authors must correctly format their bibliography to be considered as having used the macros correctly. An incorrectly formatted bibliography is not only time-consuming for SIAM to process but it is possible that errors may be introduced into it by keyboarders/copy editors.

As an alternative to the above style of reference, an alphanumeric code may be used in place of the number (e.g., [AUTh90]). The same commands are used, but `\bibitem` takes an optional argument containing the desired alphanumeric code.

Another alternative is no number, simply the authors' names and the year of publication following in parentheses. The rest of the format is identical. The macros do not support this alternative directly, but modifications to the macro definition are possible if this reference style is preferred.

8. Conclusion. Many other style suggestions and tips could be given to help authors but are beyond the scope of this document. Simple mistakes can be avoided by increasing your familiarity with how LaTeX functions. The books referred to throughout this document are also useful to the author who wants clear, beautiful typography with minimal mistakes.

Appendix. The use of appendices. The `\appendix` command may be used before the final sections of a paper to designate them as appendices. Once `\appendix` is called, all subsequent sections will appear as

Appendix A. Title of appendix. Each one will be sequentially lettered instead of numbered. Theorem-like environments, subsections, and equations will also have the section number changed to a letter.

If there is only *one* appendix, however, the `\Appendix` (with a capital letter) should be used instead. This produces only the word **Appendix** in the section title, and does not add a letter. Equation numbers, theorem numbers and subsections of the appendix will have the letter "A" designating the section number.

If you don't want to title your appendix, and just call it **Appendix A.** for

example, use `\appendix\section*{}` and don't include anything in the title field. This works opposite to the way `\section*` usually works, by including the section number, but not using a title.

Appendices should appear before the bibliography section, not after, and any acknowledgments should be placed after the appendices and before the bibliography.

REFERENCES

[1] M. Goossens, F. Mittelbach, and A. Samarin, *The* LaTeX *Companion*, Addison-Wesley, Reading, MA, 1994.
[2] N. J. Higham, *Handbook of Writing for the Mathematical Sciences*, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1993.
[3] L. Lamport, LaTeX: *A Document Preparation System*, Addison-Wesley, Reading, MA, 1986.
[4] R. Seroul and S. Levy, *A Beginner's Book of* TeX, Springer-Verlag, Berlin, New York, 1991.