Numerical vs Analytical Computation

Participated in & did the coursework [Y/N]?

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◆

1   ABSTRACT

The summary text goes here. Limit to 150 words. The summary text is a single paragraph summarizing the report's significant aspects. Do not cite references in the summary.

2   CONSPECTUS

2.1   What are the objectives of the coursework?

1) To . . . ;

2) To . . . ;

2.2   How does the coursework fit the course and previously done coursework?

By:

1) Up to two lines per item.

2) Up to two lines per item.

2.3   How were the objectives achieved?

By:

1) Up to two lines per item.

2) Up to two lines per item.

2.4   What are the key results and generalizations?

The key results are:

1) Up to two lines per item.

2) Up to two lines per item.

By affixing my/our signature/s, I/we, the author/s, pledge that: I/we have completed this coursework on my/our own; I/we have not used any unauthorized material/assistance/help on this coursework; and I/we have not given directly or indirectly to any other student/unauthorized person/means any access to any part of the specified coursework. Coram Deo.

Coursework Starting Date: Apr. 19, 2005
Submission Date: Apr. 26, 2005

3   PRINCIPLES

3.1   What are the necessary and relevant concepts, principles, theoretical and design considerations for understanding the coursework and for supporting the correct results?

1) Up to two lines per item.

2) Up to two lines per item.

3.2   How does any new component, not covered in previous coursework, function?

By:

1) Up to two lines per item.

2) Up to two lines per item.

3.3   What figures, equations, and/or tables could support your answers in Sec. 3.1 and Sec. 3.2?

1) Up to two lines per item. Figure . . . shows . . .

2) Up to two lines per item. Table . . . shows . . .

3.4   Did you cite more than two publications in your answers in Sec. 3.1 and Sec. 3.2?

Yes.

3.5   Did you cite any online source in your answers in Sec. 3.1 and Sec. 3.2?

No.

4   METHODOLOGY

4.1   How does your implementation in Sec. 4.5 achieve the objectives?

By:

1) **Objective 1 (compare numerical vs. analytical):** *Exercise 1* applies the Heron/Newton update $x_{k+1} = \frac{1}{2}\left(x_k + \frac{2}{x_k}\right)$ to approximate $\sqrt{2}$ and compares iterates to the true value; *Exercise 2* builds the Maclaurin partial sums $S_n = \sum_{k=0}^{n} \frac{x^k}{k!}$

at $x = 0.5$ and compares to $\exp(0.5)$; *Exercise 3* computes the closed-form velocity

$$v_{\mathrm{ana}}(t) = \frac{mg}{c}\left(1 - e^{-\frac{c}{m}t}\right)$$

and contrasts it with a numerical solution.

2) **Objective 2 (convergence, accuracy, efficiency):** Convergence is shown via iteration/term-vs-value plots and tables; accuracy uses absolute error tests (e.g., 10^{-12} for $\sqrt{2}$, 10^{-6} for $\mathrm{e}^{0.5}$); computational efficiency is inferred from the small number of iterations/terms needed.

3) **Objective 3 (real-world translation—fall with drag):** The model $m\dot{v} = mg - cv$ with $m = 68$ kg, $c = 12.5$ kg/s, $g = 9.8$ m/s^2 is simulated on $t \in [0, 20]$ s and compared pointwise to $v_{\mathrm{ana}}(t)$, illustrating approach to terminal velocity.

4.2 Why does your implementation in Sec. 4.5 achieve the objectives?

Because:

1) **Exercise 1** Near the root, Newton's method is quadratically convergent, so $|x_k - \sqrt{2}|$ shrinks rapidly, reaching machine-level accuracy in a few steps.

2) **Exercise 2** For e^x, the remainder is $\mathcal{O}\!\left(\frac{x^{n+1}}{(n+1)!}\right)$; factorial growth in the denominator drives fast error decay, achieving the tolerance with few terms.

3) **Exercise 3** The system admits a known solution and a stable explicit-Euler discretization with update

$$v_{i+1} = v_i + \Delta t\left[g - \frac{c}{m}\,v_i\right],$$

which, for $\Delta t = 1$ s, lies well within the stability margin $\Delta t < 2m/c$.

4.3 How does your evaluation in Sec. 4.6 achieve the objectives?

By:

1) **Error targets and logs:** Each iterate/partial sum is compared to the true value and recorded until the specified tolerance is met, quantifying convergence.

2) **Visual overlays:** Plots show approximation trajectories with horizontal reference lines (Ex. 1–2) and time-series overlays of $v_{\mathrm{num}}(t)$ vs. $v_{\mathrm{ana}}(t)$ (Ex. 3).

3) **Side-by-side tables:** For the ODE, tables list t_i, $v_{\mathrm{ana}}(t_i)$, and $v_{\mathrm{num}}(t_i)$, exposing any bias or dispersion over time.

4.4 Why does your evaluation in Sec. 4.6 achieve the objectives?

Because:

1) **Convergence behavior captured:** Ex. 1 exhibits near-quadratic decay of $|x_k - \sqrt{2}|$; Ex. 2 shows factorial-denominator error decay; Ex. 3 shows both trajectories approaching the same asymptote.

2) **Accuracy verified:** Stopping rules tied to absolute error ensure reports only when tolerances are satisfied; overlays corroborate numerically.

3) **Efficiency evidenced:** Few iterations/terms and a coarse $\Delta t = 1$ s already yield small discrepancies; refinement paths (e.g., decreasing Δt) are clear.

4.5 Implementation

4.5.1 What were the materials used?

1) MATLAB (base math functions and plotting utilities); constants g, m, c defined as parameters; iteration logs stored in arrays for tabulation/plotting.

2) Source scripts for Ex. 1–3 producing iteration histories, tables, and figures.

4.5.2 What is the summary of the processes used to make the coursework?

1) **Exercise 1** Initialize $x_0 = 1$; iterate $x_{k+1} = \frac{1}{2}\left(x_k + \frac{2}{x_k}\right)$ until $|x_k - \sqrt{2}| < 10^{-12}$; record (k, x_k); plot k vs. x_k with a reference line at $\sqrt{2}$.

2) **Exercise 2** Build $S_n = \sum_{k=0}^{n}\frac{0.5^k}{k!}$ for $n = 0, 1, \ldots$ until $|S_n - \mathrm{e}^{0.5}| < 10^{-6}$; record (n, S_n); plot n vs. S_n with a reference line at $\mathrm{e}^{0.5}$.

3) **Exercise 3** Compute $v_{\mathrm{ana}}(t) = \frac{mg}{c}\left(1 - e^{-(c/m)t}\right)$; propagate Euler $v_{i+1} = v_i + \Delta t\left[g - (c/m)v_i\right]$ with $\Delta t = 1$ s over $t = 0{:}1{:}20$ s; tabulate and overlay $v_{\mathrm{num}}(t)$ vs. $v_{\mathrm{ana}}(t)$.

4.6 Evaluation

4.6.1 What were your procedures for evaluating the correct outcome of your coursework?

1) **Deterministic error checks (Ex. 1–2):** Compare each iterate/partial sum to the corresponding ground truth; terminate when the absolute error falls below the set tolerance; confirm visually using a horizontal reference line.

2) **Pointwise trajectory comparison (Ex. 3):** For each grid time t_i, compute $v_{\mathrm{ana}}(t_i)$ and $v_{\mathrm{num}}(t_i)$, then inspect error trends and the approach to terminal velocity.

4.6.2 What quantities were gathered and how have you obtained them for testing the veracity of your results?

1) **Exercise 1:** Iteration index k and iterate x_k; absolute error $|x_k - \sqrt{2}|$.

2) **Exercise 2:** Term count n and partial sum S_n; absolute error $|S_n - \mathrm{e}^{0.5}|$.

3) **Exercise 3:** Time samples t_i, analytical velocity $v_{\mathrm{ana}}(t_i)$, and numerical velocity $v_{\mathrm{num}}(t_i)$. With $m = 68$ kg, $c = 12.5$ kg/s, $g = 9.8$ m/s^2: terminal velocity $\frac{mg}{c} \approx 53.312$ m/s. At $t = 20$ s, $v_{\mathrm{ana}} \approx 51.963$ m/s, $v_{\mathrm{num}} \approx 52.395$ m/s, a difference of ≈ 0.43 m/s ($\sim 0.83\%$ high), consistent with explicit-Euler's discretization bias at $\Delta t = 1$ s.

5 RESULTS AND DISCUSSIONS

5.1 How do the results achieve the objectives?

By:

1) Up to two lines per item.

2) Up to two lines per item.

5.2 Why do the results achieve the objectives?

Because:

1) Up to two lines per item.

2) Up to two lines per item.

5.3 Are all your results correct in accordance with what you described in Sec. 4.6 evaluation process? Why?

Yes/no, because:

1) Up to two lines per item.

2) Up to two lines per item.

5.4 What is result X (briefly describe it here), what does it mean if it is correct, and how does it contribute to reaching the objectives?

1) Refer to the appropriate caption number of your result, i.e. Fig. X for figure X, Table X for table X, etc.

2) Interpret result X and the reasons why it was obtained.

3) Point out and explain apparent discrepancies from principles/concepts/theory if your result is incorrect.

 a) Explanation 1

 b) Explanation 2

4) Cite existing publication for comparison of your result.

5) Do not present your result as "It worked" without an appropriate explanation as such action does not show thorough understanding.

6) Repeat Sec. 5.4 for each major result X (i.e. X=1, X=2, etc.).

 For example, result $X = 1$ (on the accuracy performance of the enhanced bi-directive method):

1) Figure . . . shows that the performance of the system is satisfactory up to 90%.

2) The result in Figure . . . was obtained because of the bi-directive mechanism of the proposed architecture.

3) The remaining 10% accuracy loss is due to the failure of the bi-directive mechanism to . . . and supported by . . . .

4) Reference [1] also achieved similar range of results from 85% to 93%.

5) . . .

5.5 Did you cite more than two publications in your answers above (yes/no)?

Yes.

6 CONCLUSIONS

6.1 What are the main points that should be known, remembered, and learned about the coursework?

1) Up to two lines per item.

2) Up to two lines per item.

6.2 What are the gists of the inferences drawn from your results?

6.3 Briefly, what are your comments on (1) your results, and (2) future coursework if any?

1) Up to two lines per item.

2) Up to two lines per item.

7 CREDIT AUTHOR STATEMENT

On what contributions to specify, see the terms at www.elsevier.com/researcher/author/policies-and-guidelines/credit-author-statement. An example is as follows. Follow the enumeration below in your report.

1) DELA CRUZ, Juan A.: Conceptualization, Methodology, Software, Supervision.

2) FRANCO, Nat B.: Data curation, Writing - Original draft preparation, Validation.

3) RIANZARES, Max C.: Visualization, Investigation. Software, Writing - Reviewing and Editing.

REFERENCES

[1] A. Einstein, "Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]," *Annalen der Physik*, vol. 322, no. 10, pp. 891–921, 1905.
[2] T. Oetiker, H. Partl, I. Hyna, and E. Schlegl, *The Not So Short Introduction to LaTeXe Or LaTeX 2ε in 157 minutes.* n.a., 2015.
[3] M. Shell, "How to use the IEEEtran LaTeX class. 2015."
[4] IEEE, "Preparation of Papers for IEEE Trans. J. (December 2013)."
[5] ISO, "80000-2," *Quantities and units–Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*, 2009.
[6] A. Tanenbaum, *Computer Networks*, 4th ed. Prentice Hall Professional Technical Reference, 2002.
[7] S. Lumb, S. Lumb, and V. Prasad, "Laser-induced excitation and ionization of a confined hydrogen atom in an exponential-cosine-screened coulomb potential," *Physical Review A*, vol. 90, no. 3, p. 032505, 2014.

8 ANSWERS TO QUESTIONS

Put your answers to the review/test question(s) of the coursework if included. Retain the question(s).

8.1 Question 1

1) Up to two lines per item.

2) Up to two lines per item.

8.2 Question 2

1) Up to two lines per item.

2) Up to two lines per item.

8.3 Question 3

1) Up to two lines per item.

2) Up to two lines per item.

You are seeing this because you did not specify the rubric file in the LaTeX file

APPENDIX A
INSTRUCTIONS FOR ADDRESSING SPECIFIC ITEMS IN SEC. 2 TO SEC. 8

1) Do not remove the questions in each section.

2) Generally, use normal font formatting for your answer(s).

3) Make sure that you cite references that you use.
   a) Most references should be books and not online sources.
   b) *Citing Wikipedia is not allowed*, because the veracity of its contents and authorship can be doubtful.

APPENDIX B
USAGE OF THIS TEMPLATE

1) The instructions in this template give you guidelines for preparing your report.

2) Use this document as a template, but format specific items accordingly.

3) When using the files that came with this template, it is suggested that the files and folders are intact, and not located in separate locations.

4) Graphics/images are stored primarily in the "figure" folder.

5) The rubric for assessment does not count towards the maximum number of pages of your report.

APPENDIX C
ABOUT THE TEMPLATE

1) This template was made with LATEX, which is a high-quality typesetting system.
   a) LATEX includes features designed for the production of technical and scientific documentation.
   b) LATEX is the *de facto* standard for the communication and publication of scientific documents.
   c) LATEX is available as free software.

2) In these appendices are examples of using various LATEX markup tagging conventions for formatting (headings, figures, tables, equations, etc.), styling, citing, cross-referencing, etc.
   a) *So the reader/user is expected to pay close attention to the examples and features, and adopt and use them accordingly*.
   b) Please refer to both the original report_format_template. tex and _README.pdf files.
      i) Open the the original report_format_template.tex to see how the contents of output file (_README.pdf or original report_format_template.pdf) were LATEX coded.
      ii) Open the output file (_README.pdf or original report_ format_template.pdf) file to see how the specific LATEX codes in the original report_format_template.tex file were generated.
   c) Text in this font color are blind texts throughout this template to show how a "printed" text will look like in such locations.

3) In using this template, the user is expected to have a working knowledge of LATEX, of which [2] is a good introduction (its latest version can be accessed at http://www.ctan.org/ tex-archive/info/lshort).

4) This template is adopted and based on IEEE Article Templates and Instructions (http://www.ieee.org/publications_ standards/publications/authors/author_templates.html) [3], [4]–all rights reserved.

APPENDIX D
EXAMPLE OF A SECTION HEADING

Section text here.

D.1   Example of a Subsection Heading

Subsection text here.

D.1.1   Example of a Subsubsection Heading

Subsubsection text here.

APPENDIX E
REFERRING TO SPECIFIC ITEMS

E.1   Referring to Entries in the Bibliography/References by Citing

1) Citing publications in your document using this template is accomplished using BibTeX.

2) BibTeX is reference management software for formatting lists of references and is used in the LaTeX document preparation system.
   a) JabRef is suggested for managing the BibTeX file called references.bib and other bibliographies.
   b) http://www.mcgill.ca/library/files/library/jabref_guide_ 2016.pdf may be a quick guide to using JabRef.

3) Finding the BibTeX citation on the Web can be one way of filling up necessary bibliography details.

4) The bibliography format follows the IEEE referencing style, i.e. its corresponding LATEX code is `\bibliographystyle{IEEEtr}` and the specific BibTeX file is references.bib and coded as `\bibliography{references}`, noting the extension filename ".bib" is omitted.

With the BibTeX file references.bib placed, here is an example of a citation for ISO 80000-2 standard: [5], where `\cite{ISO800002}` is used in which `ISO800002` is the BibTeX key that is specified in the BibTeX file references.bib. Another citation example: [1], [6], which is a use of more than one BibTeX key as a comma-separated list of the argument of `\cite{ }`. Please check the LATEX code how this argument was accomplished.

E.2   Referring to Sections, Figures, Tables, Equations

1) In LATEX, the specific item (section, figure, table, equation) number is referred to by making a `\label{name}`, wherein `name` is the label name beside the item.

2) To obtain the item number, refer to it using `\ref{name}` for sections, figures, or tables and using `\eqref{eqn:name}` for equations; see corresponding examples in this template.

3) When referencing your figures and tables within your report, use the abbreviation "Fig." except at the beginning of a sentence: "Figure 2 indicates . . . ."
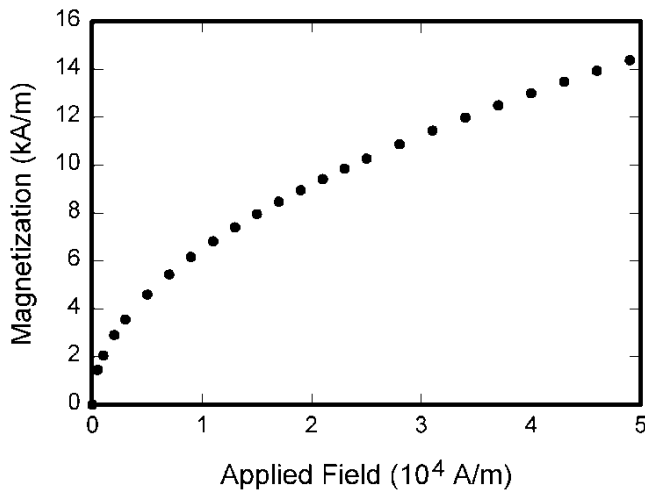
4) Do not abbreviate "Table."

Figure 1. Magnetization as a function of an applied field. In the text body, note that "Fig." is abbreviated and is used for referring to figures. *It is good practice to explain the significance of the figure in the caption.* This is a single-column figure example. PDF/JPG/PNG graphics files are supported under pdfLaTeX

5) Refer to "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ... ."

6) Do not use "Ref." or "reference" except at the beginning of a sentence: "Reference [3] shows ... ."

7) If you are quoting specific items of a programming code or command use monospace fonts, e.g. `printf("hello, world\n");`, which is accomplished by using the command `{\ttfamily printf("hello, world\n");}` in LaTeX.

APPENDIX F
EXAMPLES OF FIGURE AND TABLE PLACEMENTS

This template typically puts floats (the term for movable items such as figures and tables) only at the top, even when this results in a large percentage of a column being occupied by floats.

F.1   Figure in a Single-Column

Fig. 1 is an example of a single-column floating figure.

F.2   Figure/s in Two-Columns

1) In Fig. 2, the subfigure `\label` commands are set within each subfloat command, and the `\label` for the overall figure must come after `\caption`. `\hfil` is used as a horizontal separator to get equal spacing.

2) Watch out that the combined width of all the subfigures on a line does not exceed the text or line width, otherwise a line break will occur.

3) Be aware that for the subfig package to generate the (a), (b), etc., subfigure labels, the optional argument to `\subfloat` must be present.

4) Examples:
   a) Here is an example of referencing Fig. 2. Fig. 2a is the first figure in Fig. 2 whereas Fig. 2b is the second one.

   b) Fig. 3 is an example of one figure occupying two columns.

Table 1
Units for Magnetic Properties [4]

Symbol	Quantity	Conversion from Gaussian and CGS EMU to SI[a]
ϕ	magnetic flux	1 Mx $\rightarrow 10^{-8}$ Wb = 10^{-8} V·s
B	magnetic flux density, magnetic induction	1 G $\rightarrow 10^{-4}$ T = 10^{-4} Wb/m^2
H	magnetic field strength	1 Oe $\rightarrow 10^3/(4\pi)$ A/m
m	magnetic moment	1 erg/G = 1 emu $\rightarrow 10^{-3}$ A·m^2 = 10^{-3} J/T
M	magnetization	1 erg/(G·cm^3) = 1 emu/cm^3 $\rightarrow 10^3$ A/m
$4\pi M$	magnetization	1 G $\rightarrow 10^{-8}/(4\pi)$ A/m
σ	specific magnetization	1 erg/(G · g) = 1 emu/g $\rightarrow$ 1 A·m^2/kg
j	magnetic dipole moment	1 erg/G = 1 emu $\rightarrow$ 4p ´ 10^{-10} Wb·m
J	magnetic polarization	1 erg/(G·cm^3) = 1 emu/cm^3 $\rightarrow 4\pi$ ´ 10^{-4} T
κ	susceptibility	$1 \rightarrow 4\pi$
κ_ρ	mass susceptibility	1 cm^3/g $\rightarrow 4\pi$ ´ 10^{-3} m^3/kg
m	permeability	$1 \rightarrow 4\pi$ ´ 10^{-7} H/m = 4π ´ 10^{-7} Wb/(A·m)
μ_r	relative permeability	m $\rightarrow$ mr
W	energy density	1 erg/cm^3 $\rightarrow 10^{-1}$ J/m^3
D	demagnetizing factor	$1 \rightarrow 1/(4\pi)$

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

[a]Gaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

   c) Fig. 4 is an example of four figures occupying two columns.

   d) Fig. 5 is an example of four figures occupying one row.

   e) Fig. 6 is an example of four figures occupying one column

5) If a subcaption is not desired, just leave its contents blank, e.g., `\subfloat[]`.

F.3   Tables

1) Excel2LaTeX http://www.ctan.org/tex-archive/support/excel2latex/ is suggested as a tool for converting tables made in Excel to LaTeX.

   a) If the Excel2LaTeX add-in macro is installed correctly, after making your formatted table in Excel, use the "Convert Table to LaTeX" command in the add-in menu.

   b) Uncheck the "Booktabs-style formatting" since it is not supported in the template.

   c) Copy the Excel2LaTeX windows contents to Clipboard and then paste them in the appropriate location in your LaTeX file.

   d) Note that the `\bigstrut` is not supported in this template, so its instances should be erased after pasting the LaTeX Table code in your LaTeX file.

2) Note that, for this template, the `\caption` command should come BEFORE the table.

3) Table text will default to `\footnotesize`.

4) The `\label` must come after `\caption`.

5) Example tables are shown in Tables 1, 2, and 3. Table 4 is an example that spans two columns.

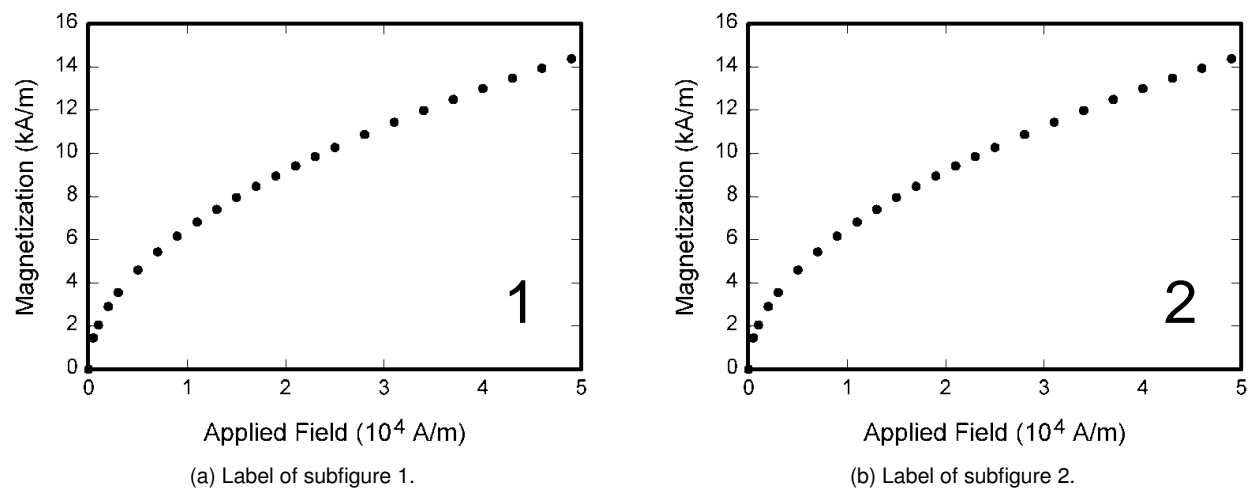(a) Label of subfigure 1.

(b) Label of subfigure 2.

Figure 2. Example of two figures in two columns.
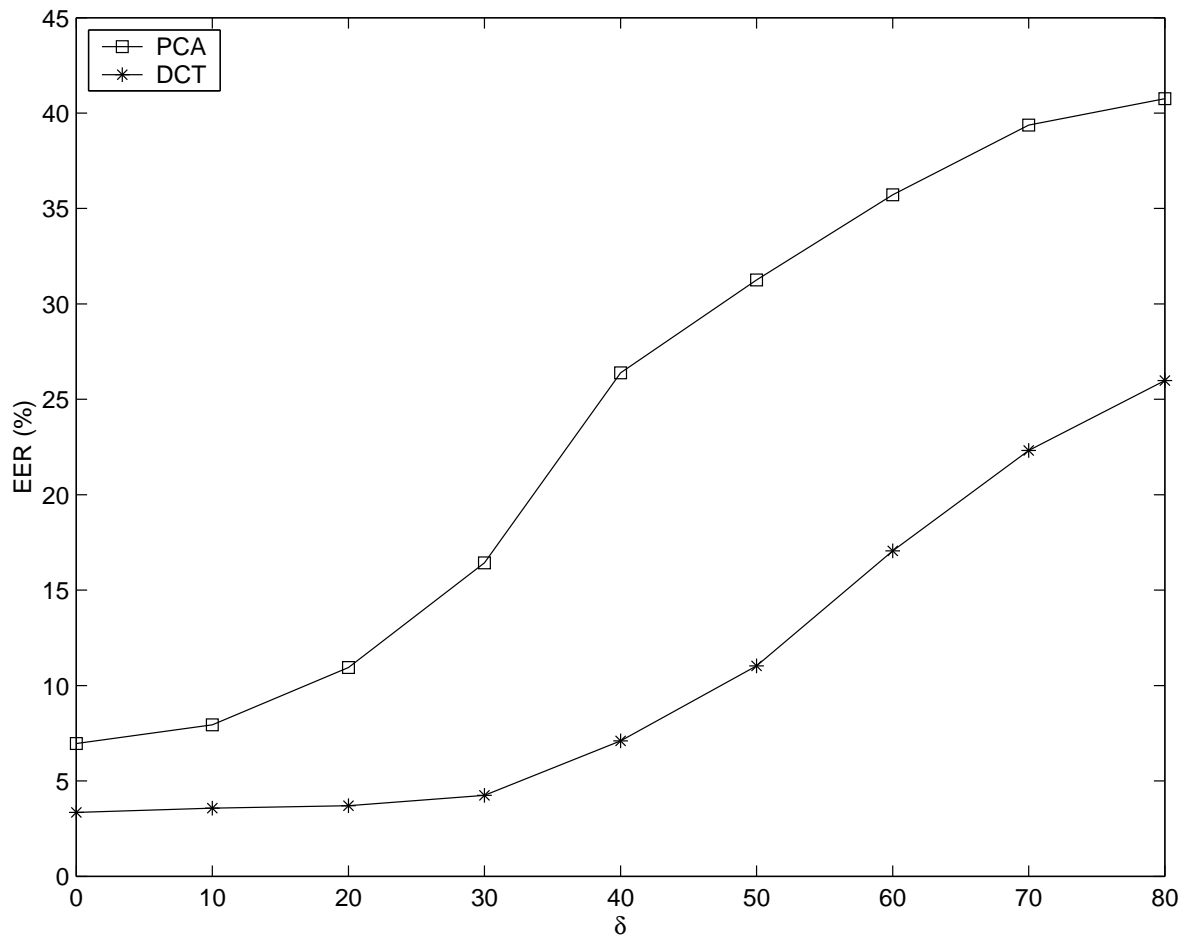
Figure 3. Example of a one figure occupying two columns.

Table 2
An Example of a Table

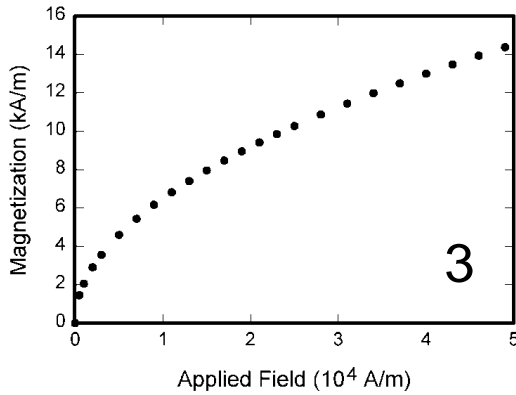| One	Two
Three	Four

APPENDIX G
EQUATION EXAMPLES

1) It is to be noted that [5] and its updates shall be used as the standard for typesetting maths like equations, variables, etc. For example, the derivative of $f(x)$ with respect to x is written as $\mathrm{d}f(x)/\mathrm{d}x$. Note that d is not italicized according
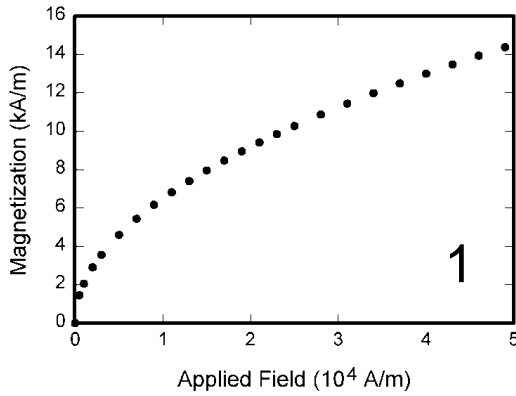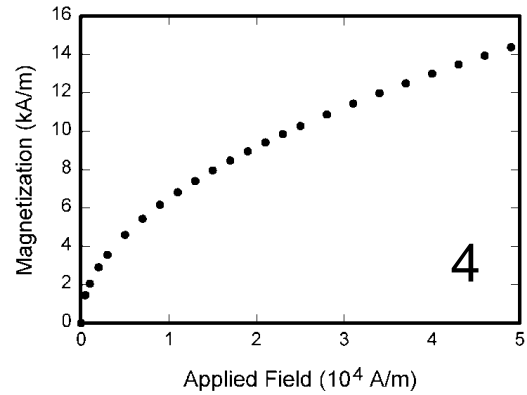
(a) Label of subfigure 1.
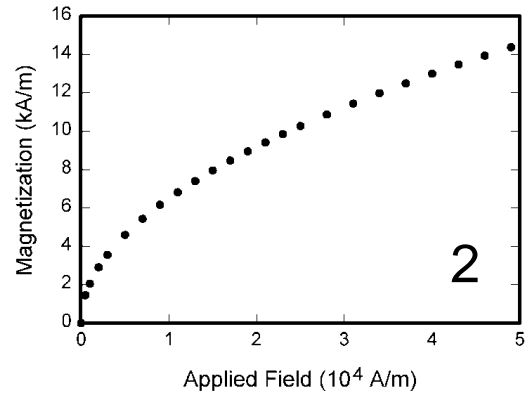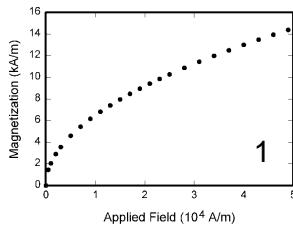
(b) Label of subfigure 2.
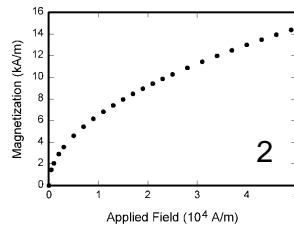
(c) Label of subfigure 3.

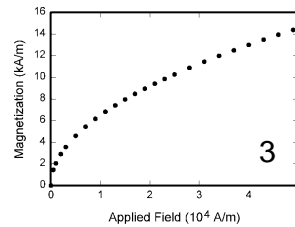(d) Label of subfigure 4.

Figure 4. Example of four figures in two columns.
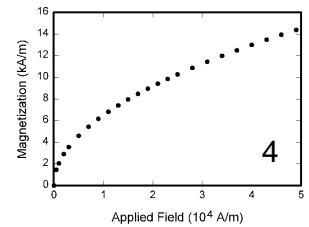

(a) Label of subfigure 1.   (b) Label of subfigure 2.   (c) Label of subfigure 3.   (d) Label of subfigure 4.

Figure 5. Example of four figures in one row.

Table 3
A Multicolumn and Multirow Table Example

T1		T2	
Player	AFG	Player	AFG
T1P1		T2P3	30
T1P2	30	T2P2	20
T1P3	15	T2P3	15

to [5].

2) EqualX and its online counterparts like https://www.codecogs.com/latex/eqneditor.ph are utilities that can be used by beginners in typesetting math in LaTeX.

3) A compiled resource of typesetting math in LaTeX can be found in http://en.wikipedia.org/wiki/Help:Displaying_a_formula.

4) In LaTeX inline equations/math are enclosed inside `$  $` delimiters, e.g. `$x_\mathrm{pos}^{-\sqrt{n}}$`, which produces $x_{\mathrm{pos}}^{-\sqrt{n}}$.

5) Displayed equations should be numbered and is handled by LaTeX when using the `eqnarray` environment (and similar).

6) Examples are shown below.
In (1), the output signal $y(t)$ is the result of the convolution of the input signal $x(t)$ and the impulse response $h(t)$.

$$y(t) = h(t) * x(t) = \int_{-\infty}^{+\infty} h(t-\tau) x(\tau) \, \mathrm{d}\tau \qquad (1)$$

Table 4

Example of a Table Occupying Two Columns. Eigenvalues (a.u.) of $n = 3, 4$ states of Confined ECSC Potential for $\delta = 0.02$ (numbers in the parentheses denote reference energies quoted from [7])

State	$r_c = 0.1$	$r_c = 0.5$	$r_c = 1$	$r_c = 2$	$r_c = 5$
$3s$	4406.1416518	170.60516396	40.883123723	9.3341469004 (9.33415)	1.0731978420 (1.07320)
$3p$	2960.4823022	114.66355228	27.493994384	6.2889991502 (6.28900)	0.7276959975 (0.72770)
$3d$	1644.5499223	63.180184177	14.987462939	3.3475046681 (3.34750)	0.3490909625 (0.34909)
$4s$	7857.6491849	308.21724725	75.150492179	17.836089963 (17.83609)	2.4023028763 (2.40230)
$4p$	5918.2028888	232.44795983	56.778032985	13.530580567 (13.53058)	1.8504011627 (1.85040)
$4d$	4115.6026320	161.37700634	39.335318864	9.3341465110 (9.33415)	1.2596272053 (1.25963)
$4f$	2426.4155489	94.646597432	22.915824203	5.3620893411 (5.36209)	0.6894218988 (0.68942)
	$r_c = 10$	$r_c = 20$	$r_c = 30$	$r_c = 50$	$r_c = 100$
$3s$	0.1113277900 (0.11133)	-0.0302492345	-0.0358787689	-0.0360250925 (-0.03603)	-0.0360251051
$3p$	0.0691008416 (0.06910)	-0.0319140038	-0.0358733580	-0.0359675961 (-0.03597)	-0.0359676034
$3d$	0.0128160637 (0.01282)	-0.0342064512	-0.0358194164	-0.0358506603 (-0.03585)	-0.0358506623
$4s$	0.4250635505 (0.42506)	0.0363462881	-0.0054277289	-0.0124953824 (-0.01250)	-0.0125717772
$4p$	0.3359680167 (0.33597)	0.0277302857	-0.0066764629	-0.0124281276 (-0.01243)	-0.0124857523
$4d$	0.2223514916 (0.22235)	0.0141166051	-0.0086778605	-0.0122798641 (-0.01228)	-0.0123102664
$4f$	0.1081309850 (0.10813)	-0.0003604550	-0.0106312256	-0.0120295162 (-0.01203)	-0.0120381878

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} \tag{2}$$

$$\frac{1}{2} < \left\lfloor \mathrm{mod}\left(\left\lfloor \frac{y}{17} \right\rfloor 2^{-17\lfloor x \rfloor - \mathrm{mod}(\lfloor y \rfloor, 17)}, 2 \right) \right\rfloor \tag{3}$$

7) To make your equations more compact, you may use the solidus (/), the exponential function, or appropriate exponents.

8) Use parentheses to avoid ambiguities in denominators.

9) Punctuate equations when they are part of a sentence, as in

$$\int_0^{r_2} F(r, \phi)\,\mathrm{d}r\mathrm{d}\phi = \left[\sigma r_2 / (2\mu_0) \right] \cdot$$
$$\int_0^{\infty} \exp\left(-\lambda \left| z_j - z_i \right|\right) \lambda^{-1} J_1(\lambda r_2) J_0(\lambda r_1)\,\mathrm{d}\lambda. \tag{4}$$

Notice that (4) is part of the sentence that just ended, thus the sentence ends in a period.

10) Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (*T* might refer to temperature, but T is the unit tesla).

11) Refer to "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ... ."

APPENDIX H
TYPOGRAPHY, SEMANTICS, AND SYNTAX-RELATED INSTRUCTIONS THAT NEED EMPHASIS

H.1 Abbreviations, Acronyms, and Units

1) Define abbreviations and acronyms the first time they are used in the text, even after they have already been defined in the abstract.

2) Abbreviations that incorporate periods should not have spaces: write "C.N.R.S.," not "C. N. R. S."

3) Do not use abbreviations in the title unless they are unavoidable.

4) Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.)
   a) English units may be used as secondary units (in parentheses).
   b) For example, write "15 Gb/cm^2 (100 Gb/in^2)."
   c) An exception is when English units are used as identifiers in trade, such as "3.5-in disk drive."
   d) Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.
   e) The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as $\mu_0 H$.
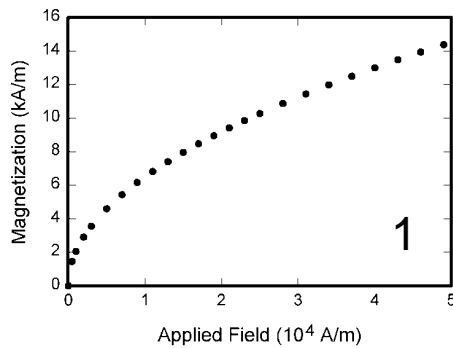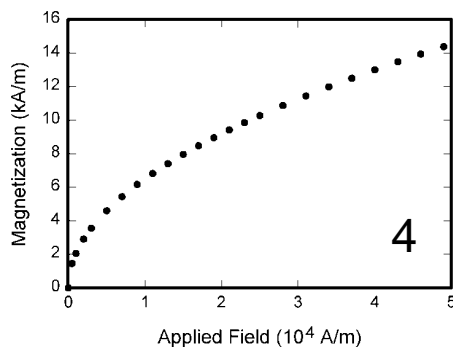
(a) Label of subfigure 1.
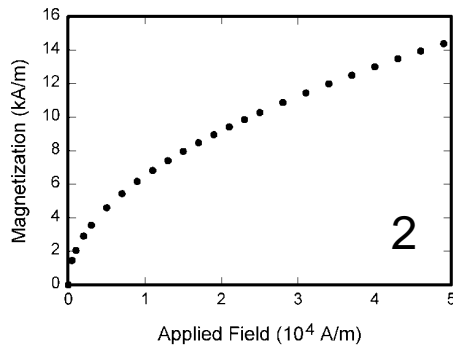
(b) Label of subfigure 2.
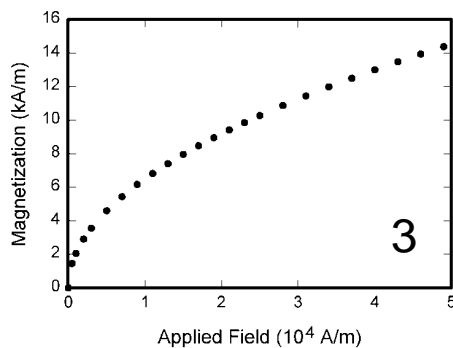
(c) Label of subfigure 3.

(d) Label of subfigure 4.

Figure 6. Example of four figures in one column.

5) Use the center dot to separate compound units, e.g., "A $\cdot$ m^2."

H.2   Some Related Technical Writing Instructions

1) Document titles should be written in uppercase and lowercase letters, not all uppercase.

2) Avoid writing long formulas with subscripts in the title; short formulas that identify the elements are fine (e.g., "Nd–Fe–B").

3) Given that table captions serve much like titles, are usually capitalized except for words such as a, an, and, as, at, but, by, for, in, nor, of, on, or, the, to, and up, which are usually not capitalized unless they are the first or last word of the caption.

4) Use one space after periods and colons.

5) Hyphenate complex modifiers: "zero-field-cooled magnetization."

6) Avoid dangling participles, such as, "Using (1), the potential was calculated." [It is not clear who or what used (1).] Write instead, "The potential was calculated by using (1)," or "Using (1), we calculated the potential."

7) Use a zero before decimal points: "0.25," not ".25."

8) Use "cm^3," not "cc."

9) Indicate sample dimensions as "0.1 cm $\times$ 0.2 cm," not "0.1 $\times$ 0.2 cm^2."

10) The abbreviation for "seconds" is "s," not "sec."

11) Use "Wb/m^2" or "webers per square meter," not "webers/m^2."

12) When expressing a range of values, write "7 to 9" or "7-9," not "7$\sim$9."

13) A parenthetical statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)

14) In American English, periods and commas are within quotation marks, like "this period." Other punctuation is "outside"!

15) Avoid contractions; for example, write "do not" instead of "don't."

16) The serial comma is preferred: "A, B, and C" instead of "A, B and C."

17) *In most technical, scientific, and academic documents, the third-person writing point of view is used.*

18) Remember to check spelling.

H.3   Some Common Mistakes

1) The word "data" is plural, not singular.

2) The subscript for the permeability of vacuum μ_0 is zero, not a lowercase letter "o."

3) The term for residual magnetization is "remanence"; the adjective is "remanent"; do not write "remnance" or "remnant."

4) Use the word "micrometer" instead of "micron."

5) A graph within a graph is an "inset," not an "insert."

6) The word "alternatively" is preferred to the word "alternately" (unless you really mean something that alternates).

7) Use the word "whereas" instead of "while" (unless you are referring to simultaneous events).

8) Do not use the word "essentially" to mean "approximately" or "effectively." Do not use the word "issue" as a euphemism for "problem."

9) When compositions are not specified, separate chemical symbols by en-dashes; for example, "NiMn" indicates the intermetallic compound $Ni_{0.5}Mn_{0.5}$ whereas "Ni–Mn" indicates an alloy of some composition Ni_xMn_{1-x}.

10) Be aware of the different meanings of the homophones "affect" (usually a verb) and "effect" (usually a noun), "complement" and "compliment," "discreet" and "discrete," "principal" (e.g., "principal investigator") and "principle" (e.g., "principle of measurement").

11) Do not confuse "imply" and "infer."

12) Prefixes such as "non," "sub," "micro," "multi," and "ultra" are not independent words; they should be joined to the words they modify, usually without a hyphen.

13) There is no period after the "et" in the Latin abbreviation "et al." (it is also italicized).

14) The abbreviation "i.e.," means "that is," and the abbreviation "e.g.," means "for example" (these abbreviations are not italicized).

15) A highly suggested style guide is available at http://www.ieee.org/web/publications/authors/transjnl/index.html

H.4   Guidelines for Graphics Preparation

1) Format and save your graphics using a suitable graphics processing program that will allow you to create the images in Portable Document Format (.PDF), PostScript (PS), Encapsulated PostScript (.EPS), Tagged Image File Format (.TIFF), or Portable Network Graphics (.PNG).

2) Make sure that the resolution setting of each figure is at least 600 dpi.

3) If you created your source files in one of the following programs: Microsoft Word, Microsoft PowerPoint, or Microsoft Excel, *it is recommended that these files be saved in PDF format* rather than DOCX, XLSX, or PPTX. Doing so will protect your figures from common font and arrow stroke issues that occur when working on the files across multiple platforms.

4) The IEEE Graphics Checker Tool at http://graphicsqc.ieee.org can help pre-screen your graphics for compliance with good publishing standards.

   a) The checker checks correct file format, resolution, size, and colorspace; that no fonts are missing or corrupt; that figures are not compiled in layers or have transparency, and that they are named according to a naming convention.

   b) At the end of the checker's automated process, you will be provided with a detailed report on each graphic within the web applet, as well as by email.

H.4.1   Accepted Fonts Within Figures

1) When preparing your graphics, it is suggested that you use one of the following Open Type fonts: Times New Roman, Helvetica, Arial, Cambria, and Symbol.

2) If you use EPS, PS, or PDF files all fonts must be embedded. Some fonts may only be native to your operating system; without the fonts embedded, parts of the graphic may be distorted or missing.

3) A safe option when finalizing your figures is to strip out the fonts before you save the files, creating an "outline" type. This converts fonts to artwork that will appear uniformly on any screen.

H.4.2   Using Labels Within Figures

1) Figure labels should be legible, approximately 8 to 10 point type as seen on the printed/100%-view output.

2) Figure axis labels are often a source of confusion, so it is better to use words rather than symbols.

   a) Write the quantity "Magnetization," or "Magnetization M," not just "M."

   b) Put units in parentheses.

   c) Do not label axes only with units. As in Fig. 1, for example, write "Magnetization (A/m)" or "Magnetization (A/m^{-1})," not just "A/m."

   d) Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

   e) Multipliers can be especially confusing.

      i) Write "Magnetization (kA/m)" or "Magnetization $(10^3$ A/m)."

      ii) Do not write "Magnetization (A/m) $\times$ 1000" because the reader would not know whether the top axis label in Fig. 1 meant 16000 A/m or 0.016 A/m.

H.5   References and Footnotes

1) Numbered footnotes are done separately in superscripts by LATEX.

2) Use letters for table footnotes (see Table 1).