I. Writing Plan Cover Page

Please fill in the gray areas on this form.

July 1st 2015

☐ Subsequent Edition of Writing Plan: previous plan submitted SP/13, First edition submitted SP/11

School of Physics and Astronomy

<table>
<thead>
<tr>
<th>WEC Unit Name</th>
<th>CSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics</td>
<td>CSE</td>
</tr>
<tr>
<td>Department</td>
<td>College</td>
</tr>
<tr>
<td>Lucy Fortson</td>
<td>Assoc Professor and Assoc Head of School</td>
</tr>
<tr>
<td>WEC Faculty Liaison (print name)</td>
<td>Title</td>
</tr>
<tr>
<td><a href="mailto:fortson@physics.umn.edu">fortson@physics.umn.edu</a></td>
<td>612-624-9587</td>
</tr>
<tr>
<td>Email</td>
<td>Phone</td>
</tr>
</tbody>
</table>

Writing Plan ratified by Faculty

Note: This section needs to be completed regardless of Writing Plan edition.

Date: June 30, 2015

If Vote: 41 / 46

# yes # total

Process by which Writing Plan was ratified within unit (vote, consensus, other- please explain):

Writing plan was presented in faculty meeting followed by a comment period and then an email vote period of ten days.
II. Unit Profile: School of Physics and Astronomy

Please fill in the gray areas on this form.

Number of Tenured and Tenure-Track Faculty:

<table>
<thead>
<tr>
<th>Faculty Level</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professors</td>
<td>47</td>
</tr>
<tr>
<td>Associate Professors</td>
<td>8</td>
</tr>
<tr>
<td>Assistant Professors</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>61</td>
</tr>
</tbody>
</table>

There are 4 other instructors for introductory courses. These instructors are also expected to implement the WEC materials in the same manner as faculty.

<table>
<thead>
<tr>
<th>Major(s)</th>
<th>Total # students enrolled in major as of Spr 2015</th>
<th>Total # students graduating with major AY 14-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS Physics</td>
<td>118</td>
<td>38</td>
</tr>
<tr>
<td>BA Physics</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>BS Astrophysics</td>
<td>41</td>
<td>14</td>
</tr>
<tr>
<td>BA Astrophysics</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>205</td>
<td>61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WEC Implementation Process</th>
<th>Semester/Year</th>
<th># participated</th>
<th># invited</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA orientation – WEC materials overview</td>
<td>Fall 2014</td>
<td>35 / 35</td>
<td></td>
</tr>
<tr>
<td>TA best practices course PHY 5072: WEC materials overview</td>
<td>Fall 2014</td>
<td>35 / 35</td>
<td></td>
</tr>
<tr>
<td>Faculty meeting reporting on WEC</td>
<td>Fall 2014</td>
<td>45 / 60</td>
<td></td>
</tr>
</tbody>
</table>
III. Signature Page

*Signatures needed regardless of Writing Plan edition. Please fill in the gray areas on this form.*

If this page is submitted as a hard copy, and electronic signatures were obtained, please include a print out of the electronic signature chain here.

**WEC Faculty Liaison**

Lucy Fortson  
WEC Faculty Liaison (print name)  
Signature

**Department Head/Chair**

Ronald A. Poling  
Print Name  
Signature

**Associate Dean**

Paul Strykowski  
Print Name  
Signature

**For College of Liberal Arts units only:**

CLA - Curriculum, Instruction, and Advising Committee approved Writing Plan on  
Signature

The Office of the Vice Provost of Undergraduate Education  
Center for Writing  
University of Minnesota  
612-626-7639  
www.wec.umn.edu
IV. Writing Plan Narrative, 3rd Edition

Please retain section headers and prompts in your plan.

Introductory Summary:
Briefly describe the reason(s) this unit (department, school, college) become involved in the WEC project, the key findings that resulted from the process of developing this plan, and the implementation activities that are proposed in this Writing Plan, with particular attention to the following questions: what is new in this 3rd edition of the Writing Plan? What, if any, key changes have been made to the 2nd edition? What key implementation activities are proposed in this edition of the Writing Plan? (1 page maximum)

This is the third edition of the writing plan for the School of Physics and Astronomy (SPA), and is heavily based on both the first and second editions. The first edition was submitted Spring 2011 for the 2011-2012 year; the second edition was submitted Spring 2013 for work from Spring 2013 through Summer 2014. This third edition is a three year plan starting Summer 2015 and focuses on finishing the work laid out in the first two editions as well as implementing strategies to embed the WEC materials and processes into the teaching infrastructure for the long term.

As stated in the first edition, SPA became involved in the WEC project for Cohort 6 because of encouragement stemming from the importance of Writing-Intensive physics courses to large numbers of majors (>200) and students (>2800 annually), especially in the College of Science and Engineering and the College of Biological Sciences. While WEC is intentionally longitudinal in nature, the vast majority of writing instruction in SPA is at the introductory level and for non-physics majors. The SPA initiative is therefore necessarily somewhat different from the core WEC intent in that it possesses two high-level components: the usual longitudinal component for majors, and a broader component focusing specifically at the introductory level for students whose further instruction will be left to other departments.

The focus of the work carried out for the first edition was on the second of these two components (the introductory courses); a wide range of WEC-related materials were created and implemented including writing guides, grading rubrics, sample labs and papers and writing workshops. The focus of the work in the second edition was on the first component (the longitudinal component for majors); many of the planned materials were developed including writing guides, grading rubrics, sample labs and papers and peer review processes. These materials were tested in PHYS 2605; further development and implementation are required to meet the objectives of the SPA WEC initiative.

With this third WEC edition, SPA requests that WEC support continue to:

1. Ensure our efforts with the introductory courses are appropriately maintained and strategically incorporated into institutional structures to enable their implementation to be carried forward even as faculty, instructors, TAs and department administrators change.
2. Focus on the continued development of WEC-related materials and resources for PHY 2605 with the goal of implementing a fully revised set in Spring 2016.
3. Determine the efficacy of developing WEC-related materials and resources for PHY 4051/4052; it is likely that these courses will only require WEC materials with a few modifications to 2605 guides particularly with respect to the presentation of projects.
4. Incorporate assessment strategies particularly in PHY 2605 and PHY 4051/52 to evaluate performance of students with respect to the desired writing abilities detailed in Section 4.
Introduction

The ability to conduct experiments, maintain a logbook of experimental progress, and present results are critical to the discipline of physics. Strong verbal and written communication skills are needed to make sure one’s ideas and results are understood. Whether students plan to attend graduate school in physics or embark on other careers immediately after graduation, they will need to be able to write research proposals, papers, and reports, in the styles expected by their employer, various funding agencies, and professional journals.

In the School of Physics and Astronomy, other writing skills such as composing well organized, complete problem solutions and writing laboratory reports are taught at the basic level in the introductory classes (1xxx-level). These classes include all CSE majors. The same skills are also taught in introductory physics classes for students from other colleges. In more-advanced classes for physics majors, these same skills are revisited in depth, and additional skills are practiced. These additional skills include writing a project proposal, writing in scientific paper style, writing and documenting software for data analysis, generating technical graphics, as well as more-advanced presentation of experimental results. Such presentations are sometimes delivered in exclusively written form and sometimes in an oral format, typically supported by appropriate graphical displays.

The WEC project has given the School of Physics and Astronomy the opportunity to reconsider the breadth, depth, consistency, and progression of writing instruction from a department-wide/curriculum-wide perspective. As is the case with every WEC unit, writing instruction in Physics involves a unique set of challenges that constrain what is appropriate and practical. Building on the two previous plans, this third edition Writing Plan presents a focused plan for improving writing instruction which is both achievable and sustainable in the sense that it does not require a long-term increase in workloads of either faculty or TAs. Outcome improvements will arise from more consistency in writing instruction across the curriculum and from making modest changes to increase effectiveness/efficiency in assigning and grading writing, rather than from dramatic changes. Indeed, surveys at the start of the WEC process showed that faculty and majors perceive current writing instruction in the department alike as acceptable, although certain improvements are definitely possible.

The School of Physics and Astronomy currently provides writing-intensive introductory courses to students from many disciplines besides physics, both from within and outside of the College of Science and Engineering. The WEC plan so far has concentrated mainly on these introductory courses; we appreciate the fact that there is interest both from the WEC program and also from around the University for the School of Physics and Astronomy to be very clear about its writing instruction in classes for non-physics majors and also responsive to the needs of other departments that rely on Physics to provide basic instruction in composing comprehensible problem solutions and reports.

Now that the writing component of our basic courses is complete, and the materials for the physics major courses drafted, we expect to finalize implementation of WEC materials for the major while at the same time ensuring long-term adoption of the work related to the introductory component.
Section 1: DISCIPLINE-SPECIFIC WRITING CHARACTERISTICS
What characterizes academic and professional communication in this discipline?

☒ There have not been substantial revisions to this section of the Writing Plan.

As a brief summary, writing in physics:

1. Involves logical, qualitative, and quantitative descriptions using skillful prose, mathematics, and graphics.
2. Includes the presentation of results and contains a description of the uncertainty of those results.
3. Includes the grounding of conclusions on basic physical principles.
4. Involves the use of visual aids (such as posters and slides) to accompany oral presentations.
5. Is organized and formatted using accepted styles appropriate for specific audiences (technical writing (academic or industrial), popular writing, etc.).

Section 2: DESIRED WRITING ABILITIES
With which writing abilities should students in this unit’s major(s) graduate?

☒ There have not been substantial revisions to this section of the Writing Plan.

On graduation, we expect physics majors as well as others to be able to:

1. Integrate physics concepts, mathematical equations, and technical graphics seamlessly into prose.
2. Clearly define physics concepts, their range of validity or uncertainty, and use them consistently in an argument.
3. Compose solutions to problems that support a logical process with appropriate mathematics, prose, diagrams, and/or graphs/tables.
4. Maintain a logbook of research activities, including figures, data tables, graphs, calculations, and explanations of ongoing work.
5. Generate reports about experiments in a range of accepted styles appropriate to the audience and situation.
6. Demonstrate an ability to communicate uncertainty in scientific results by describing the appropriate statistics.
7. Use tools for technical writing, including typesetting of mathematical symbols and equations as well as using software for analyzing data and generating technical graphics.
8. Present results in appropriate formats, including poster presentations and oral presentations (with appropriate visual aids).
9. Cite sources in APS or other professional journal style.
Section 3: INTEGRATION OF WRITING INTO UNIT’S UNDERGRADUATE CURRICULUM

How is writing instruction currently positioned in this unit’s undergraduate curriculum (or curricula)? What, if any, course sequencing issues impede an intentional integration of relevant, developmentally appropriate writing instruction?

☒ There have not been substantial revisions to this section of the Writing Plan

Writing instruction is spread across the physics undergraduate curriculum, with writing assignments primarily in the form of (a) composing technical reports (laboratory reports), (b) maintaining a laboratory logbook, and (c) generating written solutions to problems. Some of the intermediate and advanced classes also assign conceptual/historical development, educational, and/or literature-research papers.

This discussion will focus on the 3 main places in the curriculum where the majority of writing instruction occurs:

1. Introductory Physics sequences (PHYS 1301/1302 or 1401/1402 for majors as well as PHYS 1101/1102 or PHYS 1201/1202 for non-majors in certain fields)
2. Quantum Physics Laboratory (PHYS 2605)
3. Methods of Experimental Physics I and II (PHYS 4051/4052)

Introductory Class Sequences (PHYS 110xW, 120xW, 130xW, 140xV):

1. Laboratory reports: Over the course of each semester, a series of brief experiment reports (<5 pages) are required. These are organized in a fairly rigid but easily gradable format. Writing expectations are conveyed using sample reports, writing guides, and grading rubrics included in the laboratory manual as well as extra material presented usually by the TA but in some cases also by the instructor. Specific writing requirements and grading emphases depend on the faculty instructor of the course and are usually delegated to individual TAs. As part of the WEC initiative (started in Plan 1 and finalized in Plan 2), the instructions and expectations for these courses have been standardized by the development of uniform instructional materials, grading rubrics, and increased instruction to TAs. While faculty are encouraged to use these uniform materials and standards, the freedom of individual faculty has not been compromised to choose otherwise.
2. Laboratory logbooks: Students maintain a written logbook during laboratory sessions, but the detailed emphasis on this activity varies from course to course, based mostly on the instructor’s judgment. Part of the laboratory grade is based on this logbook.
3. Problem solutions: Students are expected to become proficient at solving problems and writing solutions. Students gain detailed problem-solving experience during discussion sections; these skills are assessed in quizzes and/or exams. Focus on the detail and style of written problem solutions varies widely from instructor to instructor. Extensive problem-solving materials that guide students through a specific problem-solving process are already used by some instructors, but as part of the WEC implementation, a uniform “Writing Guide for Physics Problem Solutions” has been composed for use by students in all introductory courses and is now issued to students at the beginning of each semester.

Intermediate Class (PHYS 2605):

1. Research paper: Students prepare one or more research papers (actually closer to a brief technical report, but in the format of a scientific paper). Instructions for this assignment are considered in the overall consistency-of-
expectations initiative with the intent that similar instructions will be given for student cohorts moving to PHYS 4052. Through Plan 2 work, a sample paper (actual published paper), peer review process and paper grading rubric were developed and introduced in Sp2014. A Guide to typesetting mathematics in Latex, MS Word or Google Docs was produced but not implemented.

2. Laboratory logbook: The logbook is graded more formally than in the introductory classes, so students take this type of writing assignment more seriously. An annotated sample lab report was developed and implemented in Sp2014 as part of the WEC initiative forming the basis for developing a more formalized writing guide based on and similar to that discussed above.

3. Statistical Analysis and Technical Graphs: Students receive instruction on statistics as applied to modern physics concepts and to analysis of experimental uncertainties. Students also learn about technical graphics, especially graphing experimental data and the precise calculation of error bars. The writing guide for intermediate and upper-level laboratory reports will include sections specifically on statistical analysis of data and presentation of experimental uncertainties.

**Advanced Class Sequence (PHYS 4051 & 4052W):**

1. Reports: During the first semester, students compose both “short reports” (highly structured, submitted through a web interface) and more classic “long reports” on experimental results (more thorough than in earlier classes).
2. Programming and Documenting Code: Students also learn to write well-documented programming code for data analysis.
3. Project proposal: During the second semester students compose their first-ever experiment project proposal, technical design report, and safety analysis.
4. Brief reports: Students report on progress and aspects of their experiment in a series of 2 to 3 brief reports.
5. Final Presentations in Multiple Formats: Once their experiment is done and their data analysis has been completed, students communicate their results in 3 separate modes, all of which involve writing:
   a) An oral presentation, accompanied by slides (including technical graphics),
   b) A formal research paper, 5-8 pages long, in professional journal style, and
   c) A poster presentation.

The primary structural change that has been planned for writing instruction pertains to the standardization of basic writing expectations for the introductory courses (PHYS 1101W/1102W, 1201W/1202W, 1301W/1302W, 1401V/1402V) (mostly completed), followed by enlarged sets of expectations for PHYS 2605 (and possibly PHYS 4051/4052W). These writing expectations will show a clear progression of skills aimed toward satisfying the items on the Desired Writing Ability list by the time the student graduates. Students and faculty alike should benefit from more consistency across classes and across instructors.

Through the first two plans, this standardization has been implemented in the form of separate handouts and/or appendices in laboratory manuals. Topics covered so far include (a) writing laboratory reports in introductory courses, (b) maintaining logbooks in introductory courses, (c) writing effective problem solutions, and (d) creating graphs (not included in the first edition of the plan, but created at the request of CBS). Topics to be finalized in this plan include (e) writing laboratory reports in advanced courses, (f) maintaining laboratory logbooks in advanced courses, (g) writing (journal-style) papers, (h) giving oral presentations (and generating visuals for oral presentations), and (i) making posters. When all topics are completed, they will be compiled into a stand-alone Technical Communications Handbook for physics majors (some portions of which will be applicable to non-physics-majors in introductory courses).

Writing instruction for physics majors has sometimes suffered because of significant variations in
expectations between professors and TAs in multi-section introductory courses and because of year-to-year changes in instruction in upper-level courses. Thus, faculty cannot always count on students arriving in a given class with a common set of writing skills (and other skills) already in place. Hopefully, improvements in the overall consistency in writing instruction and expectations will result in improved satisfaction about writing from students and faculty alike, as well as better alignment between writing samples taken from upper-level students and the list of Desired Writing Abilities.

Writing instruction in introductory physics courses primarily for non-physics majors has, if anything, had even wider variations and resulted, at times, in inconsistent results and generally lower satisfaction from students and faculty alike. The first edition of this plan called for follow-on surveys and ratings will be used to document the impact of the changes once implementation has been accomplished. Now that work in introductory courses is complete, these evaluations should be applied as part of Plan 3 to assess whether any further work is necessary.

The laboratory logbook is a form of writing that deserves further comment. It is somewhat unique in its lack of structure relative to many other forms of writing. Relative to the other formats presented above, it has fewer obvious parallels with traditionally recognized forms of writing or with forms of writing presented in other classes. However, the logbook is central to science. Its importance is widely recognized within the discipline; in an interview of physics instructors, performed by the WEC mentor-TA, about the importance of the desired writing abilities presented below, the maintenance of a logbook was the only ability considered critical by all respondents. The logbook also develops accurate and detailed record keeping, a skill highly valued in a variety of professional settings. However, students (especially introductory students) do not seem to appreciate the importance of this format, and often put little effort into it. It is hoped that the “Writing Guide for Physics Laboratory Logbooks” will help to emphasize the importance of this format to students, but a recommendation will be made that faculty increase the value of the grade for this format to emphasize it in a likely more effective way.

Section 4: ASSESSMENT OF STUDENT WRITING
What concerns, if any, have unit faculty and undergraduate students voiced about grading practices?

Please include a menu of criteria extrapolated from the list of Desired Writing Abilities provided in Section II of this plan. (This menu can be offered to faculty/instructors for selective adaptation and will function as a starting point in the WEC Project’s longitudinal rating process.).

There have not been substantial revisions to this section of the Writing Plan.

Course-specific writing expectations are currently explained orally and through handouts and/or laboratory manual appendices in all classes. Tying course-specific writing expectations to broader lists, like the U of M Student Learning Objectives, Discipline-Specific Writing Characteristics, and Desired Writing Abilities (Expected of Graduating Seniors), will be implemented as part of the development of consistently presented and “age-appropriate” writing instructional materials.

WEC surveys of physics faculty, teaching assistants, and physics majors were done at the start of Fall 2010. Students were generally satisfied with the writing instruction they received and felt that the introductory courses prepared them for the writing expected in the upper division courses. Faculty expressed some dissatisfaction with both the writing instruction in the lower division classes and the quality of student writing. Although none of the
three groups expressed major dissatisfaction with the writing instruction and results, there is clearly room for improvement.

A set of rating criteria has been developed (see table below) to accompany the Desired Writing Abilities list in Section #2. These criteria were first used in a one-day rating session of writing output from PHYS 4052W during the summer of 2011; a second rating session was conducted in the summer of 2014 (see Appendix I for report). The results of these ratings were shared with the departmental faculty at a faculty meeting in Fall 2014 and posted to the faculty website. It was noted that the rating criteria used did not reflect the rating criteria submitted in either Plan 1 or 2; WEC staff are being consulted on how to effectively update the criteria to best maintain longitudinal coherency in the data. In addition, a few small changes were made to the criteria based on recommendations from the rating report. Finally, it should be noted that on initial inspection, the longitudinal ratings for most of the rating criteria followed a downward trend between 2011 and 2014. There are several factors that should be considered when interpreting these data: (1) the rating scales were changed from a two-point to a four-point scale thus potentially shifting a rater’s “psychology” of response from a good/bad dichotomy in the two-point system to one where a more fine-grained response could be given; (2) the writing samples rated were on materials from courses in which the WEC plan was not yet implemented (which should be remedied by this proposal); and (3) limits imposed by sample and rating processes and procedures. To this last point, we would like to work with WEC staff to increase the number of in-domain raters as we believe that to obtain accurate ratings, many of the criteria require domain-specific technical knowledge.

In preparation of the first plan, Professor Bill Zimmerman performed an independent analysis of senior-level writing after the development of the rating criteria. Although phrased differently and more explicitly based on physics and scientific methodology, his criteria were almost entirely in-line with or implicit in those in the table below, and so that table has not been revised. They nevertheless were used to inform and supplement those criteria. Faculty will continue to be encouraged to utilize the rating criteria as well, to assess other required writing in both lower and upper division courses.

**Rating Criteria Table, to accompany list of Desired Writing Abilities for graduating seniors.**

<table>
<thead>
<tr>
<th>Desired Writing Abilities</th>
<th>Proposed Criteria for Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>(for graduating seniors in the discipline)</td>
<td>A. Focus is on the text.</td>
</tr>
<tr>
<td></td>
<td>B. How will each ability be evidenced in the text?</td>
</tr>
<tr>
<td></td>
<td>C. We have the raters respond to this question:</td>
</tr>
<tr>
<td></td>
<td><em>Does the text sufficiently or insufficiently demonstrate this criteria at the level you would expect for a graduating senior?</em></td>
</tr>
<tr>
<td>Physics majors, upon graduation, will be able to:</td>
<td></td>
</tr>
<tr>
<td>1. Integrate physics concepts, mathematical equations, and technical graphics seamlessly into prose.</td>
<td>1A. Seamlessly integrates physics concepts and mathematical equations into prose using comprehensive in-text references.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1B.</td>
<td>Seamlessly integrates technical graphics into prose by using in-text references, titles, and appropriate captioning format.</td>
</tr>
<tr>
<td>1C.</td>
<td>Provides appropriate numbering protocol for in-text references in the case of equations. (Added plan 3)</td>
</tr>
<tr>
<td>2.</td>
<td>Clearly define physics concepts and use them consistently in an argument.</td>
</tr>
<tr>
<td>2A.</td>
<td>Clearly defines and demonstrates understanding of relevant physical concepts.</td>
</tr>
<tr>
<td>2B.</td>
<td>Consistently uses the defined concepts in arguments.</td>
</tr>
<tr>
<td>3.</td>
<td>Compose solutions to problems that support a logical process with appropriate mathematics, prose, diagrams, and/or graphs/tables.</td>
</tr>
<tr>
<td>3A.</td>
<td>Composes comprehensible problem solutions.</td>
</tr>
<tr>
<td>3B.</td>
<td>Adequately supports solutions with diagrams and/or logical explication of work, assumptions, and limitations.</td>
</tr>
<tr>
<td>4.</td>
<td>Maintain a logbook of research activities, including figures, data tables, graphs, calculations, and explanations of ongoing work.</td>
</tr>
<tr>
<td>4A.</td>
<td>Records all information necessary for reproduction of the experiment as performed.</td>
</tr>
<tr>
<td>4B.</td>
<td>Uses style and formats appropriate to record information quickly and clearly.</td>
</tr>
<tr>
<td>5.</td>
<td>Generate reports about experiments in a range of accepted styles appropriate to the audience and situation.</td>
</tr>
<tr>
<td>5A.</td>
<td>Uses style based on that of scientific paper (containing abstract, introductory material, description of methods and materials, and discussion of results).</td>
</tr>
<tr>
<td>5B.</td>
<td>Formats reports using consistent and logical headings.</td>
</tr>
<tr>
<td>5C.</td>
<td>Includes cohesive description of experimental procedures.</td>
</tr>
<tr>
<td>6.</td>
<td>Demonstrate an ability to communicate uncertainty in scientific results by describing the appropriate statistics.</td>
</tr>
<tr>
<td>6A.</td>
<td>Represents, in graphics, mathematics, and/or prose, the kinds of statistics and principles used to identify and quantitatively analyze uncertainties.</td>
</tr>
<tr>
<td>7.</td>
<td>Use tools for technical writing, including typesetting of mathematical symbols and equations as well as using software for analyzing data and generating technical graphics.</td>
</tr>
<tr>
<td>7A.</td>
<td>Uses tools for technical writing, including software for mathematical typesetting and for generating technical graphics.</td>
</tr>
</tbody>
</table>
8. Present results in appropriate formats, including poster presentations and oral presentations (with appropriate visual aids).

8A. Implements stylistic features specific and appropriate to diverse formats.

8B. Writings in distinct formats about same or similar subjects complement one another.

9. Cite sources in APS or other professional journal style.

9A. Consistently cites sources using APS or other professional journal style.


10A. Conforms to standard Academic American English usage and mechanics.

Section 5: SUMMARY OF IMPLEMENTATION PLANS, including REQUESTED SUPPORT, RELATION TO PREVIOUS IMPLEMENTATION ACTIVITIES, and SUSTAINABILITY PLANS

What does the unit plan to implement during the period covered by this plan? What forms of instructional support does this unit request to help implement proposed changes? What are the expected outcomes of named support?

How do the implementation plans of the 3rd edition Writing Plan relate to implementation activities from the 1st and 2nd edition Writing Plans? What has been successful? What was not successful? How do implementation plans build on what was learned from the first year of implementation? How do implementation plans anticipate the ongoing application of this final edition Writing Plan?

How will the unit move toward ownership of the implementation process after the end of eligibility for WEC funding? When needed, what will be sources of funding and resource support? How will ongoing evaluation and improvement of the Writing Plan take place?

Implementation Activities from the First- and Second-Edition Plans:

The second edition of the SPA WEC writing plan was a continuation of the first plan. The three major objectives of the original plan remained largely the same and are enumerated below. Beneath each of the three objectives we provide the implementation activities as they were carried out in the first plan (P1) and/or the second (P2).

1. The funding of a WEC mentor-TA to develop materials for writing instruction (primarily “writing guides”) and to work with faculty and TAs at all levels to address writing issues.
   a. Focus on developing materials for introductory courses (P1) and implementation thereof (P2).
   b. Focus on developing materials for upper level courses for majors (P2) and initial implementation thereof (P2).
2. (Work with WEC staff to) offer a series of workshops on specific writing issues including, but not limited to, effective assignments, useful feedback, grading efficiently, and dealing with logistical challenges of large classes.
   a. Focus on TA training for introductory courses (P1) (P2)
3. (Work with WEC staff to) conduct and analyze WEC-style surveys of faculty and students from other departments to improve alignment between their needs and the writing instruction and assignments in introductory courses.
a. Informal consultations with departments served by introductory physics courses and implementation of requests (P1)

It is clear that, so far, the major outcomes of the WEC initiative in SPA strongly focus on the introductory courses. In preparation for this third writing plan, a review of introductory materials generated by the WEC initiative show that all proposed materials have been generated. These include Writing Guides for Lab Reports and Problem Solutions, related grading rubrics plus sample good and bad lab reports. These were made available to students originally through the printed lab manuals and now through interactive online versions. In addition, seven separate Five Minute Writing Workshops were developed for use by the introductory course TAs to aid in student comprehension of writing expectations for the various sections of a lab report. A sample of a Five Minute Writing Workshop is included in Appendix II.

However, while the WEC initiative is a topic of several sessions during TA training and the Best Practices course (PHYS 5072), it is not evident that the implementation of the materials is discussed beyond a brief mention. Additionally, many of the faculty who had been teaching introductory courses during the initial phases of WEC implementation have rotated out while an expansion of new hires has populated the introductory courses with faculty who may or may not be aware of the WEC initiative materials. Finally, while the second writing plan yielded significant progress in developing and initial implementation of WEC-related materials for PHY 2605, in a review of these materials for the third plan, it is clear that improvements can and should be made. The Typesetting Mathematical Equations guide and PHYS 2605 Sample Logbook are included in Appendix II.

PHYS 4051/4052 have received very little attention from the SPA WEC initiative apart from informal discussions with several faculty and TAs who have taught the course. That said, the current curriculum materials used for 4051/52 are reasonably well-aligned with the consistency-of-expectation initiative for writing that is one of the major aspects of the WEC initiative for SPA. For example, 4052 already provides sample lab reports, rubrics, papers, and presentations as well as clear instructions on what is expected from each aspect of the course that generally aligns with the Desired Writing Abilities (e.g. using graphics or equations in presentations). It also already utilizes the peer review process for the multiple stages of their capstone project (e.g. safety report, technical design review, project reports). Nonetheless, it is expected that a review of these materials by the WEC TA will likely identify specific areas of improvement particularly with respect to consistency in expectations for writing between 2605 and 4051/52.

Based on this assessment, the path forward for the third WEC writing plan for SPA is to:

1. Ensure our efforts with the introductory courses are appropriately maintained and strategically incorporated into institutional structures to enable their implementation to be carried forward even as faculty, instructors, TAs and department administrators change.
2. Focus on the continued development of WEC-related materials and resources for PHY 2605 with the goal of implementing a fully revised set in Spring 2016. Additionally, these resources will also be included in the efforts under (1) above.
3. Determine the efficacy of developing WEC-related materials and resources for PHY 4051/4052; it is likely that these courses will only require WEC materials with a few modifications to 2605 guides particularly with respect to the presentation of projects and writing of final papers.
4. Incorporate longitudinal assessment strategies particularly in PHY 2605 and PHY 4051/52 to evaluate performance of students with respect to the desired writing abilities detailed in Section 4.
Implementation Plans for SPA Writing Plan Three:

As described above, there are four parts to the third writing plan. Detailed implementation goals are listed below for each of the four aspects:

1. Part I: Introductory courses – focus on long-term implementation and maintenance of WEC with steps that should help protect against continual turn-over in faculty who teach introductory courses.
   a) Faculty level
      i) Write up one page reference document on WEC materials and their purpose; provide as permanent post in all introductory level course web-folders; post on all-faculty department website resource page.
      ii) Work with 5072 instructor(s) to develop TA training and best practices guidelines that include WEC material training; ensure that these guidelines are posted to the 5072 website resource page for instructors.
   b) TA level
      i) Gather all WEC-related guidelines, materials, instructions and documentation and post on TA’s reference website for introductory courses. These will be referred to and discussed in the TA training and 5072 best practices course.
      ii) Include development and/or refinement of “Five-minute workshop” examples in 5072 as a dual mechanism for practicing their implementation as well as continued generation of a pool of effective workshops.
      iii) Request WEC workshops for:
            (1) TA training just prior to beginning of each academic year
            (2) PHYS 5072

2. Part II: Phys 2605
   a) Develop materials and write a guide to enable students to produce more advanced lab reports than at the introductory level with an eye towards preparing students for 4051/4052. This will likely incorporate:
      i) Guidelines to keeping a well-organized and detailed lab logbook; these guidelines will include revisions to current annotated sample lab notes.
      ii) Several actual 2605 lab reports (obtained through WEC) that exemplify best practices as well as point to common mistakes.
      iii) Mathematical equation typesetting guide produced in Plan Two
      iv) Guide to presentation of graphs and figures appropriate to this intermediate level
      v) Guide to presentation of experimental uncertainties, systematic error analysis and statistical analysis of data (including data fitting routines) appropriate to this intermediate level.
      vi) Revise lab report grading rubric as needed
   b) Develop materials and write a guide to enable students to write papers that emulate professional journal-style articles. This will likely incorporate:
      i) Revisions to current annotated sample journal article produce in Plan Two.
      ii) Several actual 2605 papers (obtained through WEC) that exemplify best practices as well as point to common mistakes.
      iii) Mathematical equation typesetting guide produced in Plan Two
      iv) Guide to presentation of graphs and figures appropriate to this intermediate level – modified from lab report guide as appropriate to journal paper formats.
      v) Guide to presentation of experimental uncertainties, systematic error analysis and statistical analysis of data (including data fitting routines) appropriate to this intermediate level – modified from lab report guide as appropriate to journal paper formats.
      vi) Guide to peer-review and its implementation in the paper-writing assignments in this course.
      vii) Revise paper-grading rubric as needed.
Request WEC assistance in developing best-practices for peer-review – this may involve a workshop for faculty as well as potentially TAs.

3. Part III: Phys 4051/4052
   a) Based on currently used material, refine guidelines for best-practices in writing project proposals, writing and delivering oral slide presentations as well as poster presentations.
   b) Work with current and former faculty to assess whether:
      i) Minimal adaptations to any of the guides produced for 2605 would be appropriate and useful.
      ii) TAs might play a role in facilitating an increased focus on WEC-related outcomes (e.g. include a component of TA-grading to the intermediate stages of the experimental project logbook).
   c) Request WEC assistance in developing best-practices for peer-review – this may involve a workshop for faculty as well as potentially TAs.

4. Part IV: Assessment
   a) Work with WEC staff to develop appropriate grading rubrics for lab write-ups and papers graded for PHY 2605 and PHY 4051/52. It is important to note that while these rubrics will incorporate evaluations of the desired writing outcomes detailed in Section 4 appropriate to each course, the rubrics would not require any additional work than normal on the part of faculty or TA in grading.
   b) Work with WEC staff to interpret the results of data collected from the graded lab write-ups and papers. This will include longitudinal comparisons between student cohorts taking PHY 2605 followed by 4051/52 in the subsequent year to determine if the desired writing outcomes introduced in 2605 transferred to 4051/52. We will also work with WEC staff to investigate best practices for longitudinal comparisons with a particular focus on knowledge transfer within student cohorts.
   c) Work with WEC staff to develop connections with other WEC units for whom intro physics is a required course to examine alignment between goals and expectations common to our writing plans.

Work for Plan Three will be carried out primarily by new WEC mentor-TA (Julie Vievering) who was a SPA mentor-TA in 2013-14 and lead mentor-TA in 2014-15; she therefore has excellent experience in TA training and will be invaluable in determining mechanisms that are most likely to succeed for incorporating WEC-related materials into long-term sustainable structures. For all four parts of the current writing plan, Julie will work in consultation with SPA Associate Head and WEC-liaison Lucy Fortson; we expect to consult with WEC staff as we proceed and will request as appropriate their involvement in workshops and evaluations.

For Part I, faculty members Yuichi Kubota and Cindy Cattell will also be consulted on best strategies for sustainable implementation of introductory material in PHYS 5072. Kubota and Fortson have recently taught this course; Cattell is expected to teach it for the 2015-16 academic year. The physics department requires extensive training be given to the TAs responsible for teaching introductory courses through departmental TA orientation in the first two weeks of the academic year and during Phys 5072, the mandatory year-long seminar for new TAs. Vievering will incorporate the following into the guidelines for the curricula for both of these activities: the WEC initiative as a whole, its goals, what to expect from it, what resources are available to students and TAs, and how TAs could address various issues with student writing in their courses. We will also detail how to request WEC staff to help implement some of these sessions where appropriate.

For Part II, Vievering will work more directly with SPA faculty member C. C. Huang who has taught PHYS 2605 on the first round of WEC material implementation and who will teach it again in Spring 2016. The department is funding one week of Huang’s time in Summer 2015 to work with Vievering on materials revisions and development. Additionally, Vievering will consult with faculty member Jeremiah Mans who is teaching 2605 in Fall 2015. Finally, Vievering will implement WEC-related work as a TA for 2605 in Spring 2016 along with two repeat 2605 TAs.
For Part III, faculty for 4051/4052 will be consulted by Fortson and Vievering on how WEC materials could be incorporated into their course.

For Part IV, Vievering will work with Fortson, Huang and WEC staff to design rubrics as appropriate.

**Summer 2015**

Work will start late August 2015 with a series of separate kick-off meetings for each of the four plan components including the appropriate faculty stake-holders listed above. We request funds for Vievering to be employed via WEC at 1/4 time (10 hours per week) starting August 24, 2015. She will ensure that appropriate WEC-related materials are included in the 2015 two-week TA training and develop a plan for continued work on Part I through Fall 2015. For Part II, she will work with Huang and do a careful review of all labs and papers assigned in 2605 and will aim to revise or develop any materials based on her findings. For Part III, Fortson will use the kick-off meeting to consult with 4051 faculty and develop a plan to implement any WEC-related structural changes to TA grading in the course. Work with WEC staff to determine the relevant workshops for the year. In addition to the TA training workshops, these will likely break down into at least one workshop in the fall 2015 and spring 2016 semesters for faculty and TAs.

**Fall 2015**

We request funds for Vievering to be employed at 1/4 time via WEC funds for the Fall semester. She will carry out the Part I implementation plan and finish developing the Part II products. For Part III, Fortson will continue to consult with appropriate faculty to monitor any implementation of WEC-related changes. The assessment materials for Part IV will also be developed informed by the 2014 WEC ratings.

**Spring 2016**

We request funds for Vievering to be employed at 3/8 time via WEC funds for the Spring semester. She will finalize as needed any of the Part I implementation plans while the majority of her time will be spent in fully implementing Part II as a ¼ time 2605 TA. For Part III, Fortson will work with Vievering who will write any of the WEC-related guides decided on as part of the consultations with 4051/4052 faculty. Part IV assessment data will be taken in 2605 and 4051/52.

**Summer 2016**

We request funds for Vievering to be employed 4 weeks full time via WEC funds in May 2016 after the semester is finished to finalize any changes to Part I, II or III materials and ensure that any revisions needed to implementation work are appropriately documented. Assessment data will be analyzed with assistance of WEC staff.

**Years Two and Three**

The intent of the first year of this third writing plan is to put in place the structures that will enable the School of Physics and Astronomy to naturally utilize WEC materials as developed. The responsibility of monitoring whether the system is working or not will fall on the WEC faculty liaison and the instructor(s) for 5072 (for the introductory course materials). For 2605 and 4051/52, the WEC liaison will meet with instructors for those courses along with the lead TAs to inform them of the importance of using the assessment rubrics as designed along with the other WEC materials developed for those courses. The lead TA will be responsible for recording the assessment data; the WEC
The Office of the Vice Provost of Undergraduate Education  
Center for Writing  
University of Minnesota  
612-626-7639  
www.wec.umn.edu

liaison will be responsible for working with WEC staff on interpretation of the assessment data. Throughout years two and three, the WEC liaison will work with the Director of Undergraduate Studies to ensure that that office can take responsibility for monitoring the usage of the WEC materials moving into the out years beyond the third writing plan. We will continue to consult with WEC staff as appropriate and request assistance with workshops for TA training.

Context regarding TAs in Physics: Unlike procedures in some departments, the Physics Department closely supervises all TAs, and none are ever assigned to teach a class of their own. All new TAs, both graduate students and undergraduates, are required to attend a 10-day TA training course before the start of fall semester to introduce them to, among other things, writing expectations and assessment, grading of problem solutions, and etcetera. Three “mentor-TAs” are supported by the school to assist with TA summer orientation and with the required year-long TA seminar (PHYS 5072), entitled “Best Practices in College Physics Teaching,” in which writing and many additional topics are discussed in more detail. The WEC mentor TA in this proposal is in addition to these mentor TAs but for the goal of creating a sustainable model, it is foreseen that these mentor TAs will take on the long-term aspects of the WEC implementation.

Context regarding potential workshops on writing: In the WEC surveys of faculty and TAs collected in fall 2010, both groups indicated an interest in opportunities to learn more about and discuss effective and efficient assessment of student writing. Faculty were particularly interested in exploring how to design effective writing assignments and how to make the most use of feedback. TAs, unexpectedly, were more interested in strategies to grade efficiently. The existing TA orientation and follow-on Best Practices class provides a direct route for presentations and short workshops to be delivered to TAs. Faculty, especially those in the courses most impacted by the WEC Writing Plan, have also expressed interest in workshop opportunities. Details of how such workshops might be offered have yet to be worked out, and department-wide faculty attendance will not be required. Depending on the topic, some writing presentations may be delivered to TAs and faculty together.

Section 6: PROCESS USED TO CREATE THIS WRITING PLAN

How, and to what degree, were a substantial number of stakeholders in this unit (faculty members, instructors, affiliates, teaching assistants, undergraduates, others) engaged in providing, revising, and approving the content of this Writing Plan?

This writing plan is primarily based on the first edition writing plan as well as aspects of the second. Section #6 from the first plan is included verbatim as Appendix III. Plan 2 was prepared from the first edition primarily by temporary WEC Faculty Liaison Thomas Walsh and heavily revised by WEC mentor-TA Allan Straub, incorporating new information regarding progress and revision that occurred since the first edition's approval. This third plan was prepared by new SPA WEC Faculty Liaison Lucy Fortson in consultation with Pamela Flash and Daniel Emery of WEC, the SPA Head of School Ron Poling, the SPA DUGS Jeremiah Mans and the faculty instructor for PHY 2605 C. C. Huang as well as faculty instructor for 4052 Clem Pryke. Previous WEC TA Allan Straub as well as WEC liaison Walsh were consulted on the implementation of Plan 2. Faculty members Cattell, Huang, Kapusta, Kubota, Mans and Poling were given the opportunity to comment on formative drafts of the third plan. Emery from WEC also provided comments on formative drafts. The structure of the third plan was presented by Fortson at a faculty meeting on March 23, 2015 with opportunity for comment. The full plan was presented by Fortson at a faculty meeting on April 27, 2015. A two-week comment period followed. After revisions, the final version of the plan was submitted to
the faculty on June 20, 2015 with a formal faculty vote for approving the final plan conducted via email. The final plan was thus approved by the faculty with a 75% turnout: 41 faculty voted yes and five abstained. There were no “no” votes.

It is worth noting that the liaison for the preparation of the first-edition plan, James Flaten, was a faculty member of the Aerospace Engineering and Mechanics Department, and not a member of SPA. Upon approval of the plan, Cindy Cattell, the Associate Head of the School of Physics and Astronomy, took over the role of faculty liaison. However, Cindy Cattell soon required an extended medical leave, Thomas Walsh was then appointed to assume the role in her absence and subsequently Lucy Fortson was appointed WEC Faculty Liaison.

Section 7: CONNECTION TO STUDENT LEARNING OUTCOMES

Briefly describe how the ideas contained in this Undergraduate Writing Plan address the University's Student Learning Outcomes (http://www.slo.umn.edu).

The University of Minnesota Student Learning Outcomes (SLOs) state that

*at the time of receiving a bachelor's degree, students:*

1. Can identify, define, and solve problems
2. Can locate and critically evaluate information
3. Have mastered a body of knowledge and a mode of inquiry
4. Understand diverse philosophies and cultures within and across societies
5. Can communicate effectively
6. Understand the role of creativity, innovation, discovery, and expression across disciplines
7. Have acquired skills for effective citizenship and life-long learning

The Desired Writing Abilities in the Physics Writing Plan align with the SLOs as shown in the following table.
<table>
<thead>
<tr>
<th></th>
<th>Can locate and critically evaluate information</th>
<th>Can identify, define, and solve problems</th>
<th>Have mastered a body of knowledge and a mode of inquiry</th>
<th>Understand diverse philosophies and cultures within and across societies</th>
<th>Can communicate effectively</th>
<th>Understand the role of creativity, innovation, discovery, and expression across disciplines</th>
<th>Have acquired skills for effective citizenship and lifelong learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Integrate physics concepts, mathematical equations, and technical graphics seamlessly into prose.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Clearly define physics concepts and use them consistently in an argument.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Compose solutions to problems that support a logical process with appropriate mathematics, prose, diagrams, and/or graphs/tables.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Maintain a logbook of research activities, including figures, data tables, graphs, calculations, and explanations of ongoing work.</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Generate reports about experiments in a range of accepted styles appropriate to the audience and situation.</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Demonstrate an ability to communicate uncertainty in scientific results by describing the appropriate statistics.</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Use tools for technical writing, including typesetting of mathematical symbols and equations as well as using software for analyzing data and generating technical graphics.</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Present results in appropriate formats, including poster presentations and oral presentations (with appropriate visual aids).</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Cite sources in APS or other professional journal style.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Conform to standard Academic American English.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX I – Rating Report of Physics

Physics:
Rating upper-division writing of graduating majors
June 19, 2014

Method: A team of three independent raters (two from inside the discipline, and one a writing specialist) scored capstone-level writing collected from this unit. Raters used a four-point criterion-referenced scale, assessing student works as “insufficient,” “approaching sufficiency,” “sufficient,” or “more than sufficient” for capstone-level writing for each criterion provided by the unit (this list is drawn from the unit’s Writing Plan). No cumulative scores were given. Prior to rating student writing, raters were provided a “training” session by a faculty member drawn from inside the unit. During this session, criteria were discussed and anchor papers were rated. After the rating session, raters were debriefed on the student work and rating process.

Results: Where 0 is complete (three-rater) agreement on “Insufficient,” 1 is complete agreement on “Approaching Sufficiency,” 2 is complete agreement on “Sufficient,” and 3 is complete agreement on “More than Sufficient.” Each rating represents an average of all raters’ scores for all writing samples for each criterion.

<table>
<thead>
<tr>
<th>#</th>
<th>Criteria</th>
<th>2014(^1)</th>
<th>2014 Physics Raters only</th>
<th>2014 Writing Specialist only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seamlessly integrates physics concepts and mathematical equations into prose using comprehensive in-text reference, and in the case of equations, appropriate numbering protocol.</td>
<td>1.64</td>
<td>1.58</td>
<td>1.75</td>
</tr>
<tr>
<td>2</td>
<td>Seamlessly integrates technical graphics into prose by using in-text references, titles, and appropriate captioning format.</td>
<td>1.33</td>
<td>1.21</td>
<td>1.58</td>
</tr>
<tr>
<td>3</td>
<td>Adequately supports solutions results with diagrams and/or logical explication of work, assumptions, and limitations.</td>
<td>1.85</td>
<td>1.86</td>
<td>1.83</td>
</tr>
<tr>
<td>4</td>
<td>Uses style based on that of scientific paper (containing abstract, introductory material, description of methods and materials, and discussion of results).</td>
<td>1.67</td>
<td>1.63</td>
<td>1.75</td>
</tr>
<tr>
<td>5</td>
<td>Formats reports using consistent and logical headings.</td>
<td>1.86</td>
<td>1.88</td>
<td>1.83</td>
</tr>
<tr>
<td>6</td>
<td>Adequately prepares reader for analysis of results by conveying (1) what was done in the experimental procedure, (2) why it was done, and, where applicable, (3) what didn’t work.</td>
<td>1.81</td>
<td>1.75</td>
<td>1.92</td>
</tr>
<tr>
<td>7</td>
<td>Presents results using graphics, mathematics, and/or prose.</td>
<td>1.97</td>
<td>1.96</td>
<td>2.0</td>
</tr>
<tr>
<td>8</td>
<td>Analyzes results and describes methods used in doing so.</td>
<td>1.79</td>
<td>1.77</td>
<td>1.83</td>
</tr>
<tr>
<td>9</td>
<td>Identifies and quantitatively analyzes errors and uncertainties. This should include discussion of fitting parameters and their uncertainties.</td>
<td>1.66</td>
<td>1.50</td>
<td>2.0</td>
</tr>
<tr>
<td>10</td>
<td>Uses tools for technical writing, including word-processing of mathematical equations and software-generated graphs.</td>
<td>1.92</td>
<td>1.88</td>
<td>2.0</td>
</tr>
<tr>
<td>11</td>
<td>Consistently cites sources using APS or other professional journal style.</td>
<td>1.50</td>
<td>1.42</td>
<td>1.67</td>
</tr>
<tr>
<td>12</td>
<td>Conforms to standard American Academic English usage and mechanics.</td>
<td>1.56</td>
<td>1.46</td>
<td>1.75</td>
</tr>
</tbody>
</table>

\(^1\) Samples collected from PHYS 4502W, Spring 2014, N = 12
Longitudinal Analysis of Ratings: Physics

In 2014, following a 2013 pilot study conducted by the Office of Institutional Research, the WEC rating scale was changed from a 2-point scale (insufficient, sufficient) to a 4-point scale (insufficient, approaching sufficiency, sufficient, more than sufficient). To continue providing WEC units with longitudinal data, we report on current results (see above) using the new scale and longitudinal results (see below) by collapsing current data as follows:
- “insufficient” and “approaching sufficiency” = insufficient(0)
- “sufficient” and “more than sufficient” = sufficient(1)

<table>
<thead>
<tr>
<th>#</th>
<th>Criteria</th>
<th>2011</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seamlessly integrates physics concepts and mathematical equations into</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>prose using comprehensive in-text reference, and in the case of equations,</td>
<td>0.94</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>appropriate numbering protocol.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Seamlessly integrates technical graphics into prose by using in-text</td>
<td>0.85</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>references, titles, and appropriate captioning format.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Presents logically composed solutions to computational problems.</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>Adequately supports\ solutions results with diagrams and/or logical</td>
<td>NA</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>explication of work, assumptions, and limitations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Uses style based on that of scientific paper (containing abstract,</td>
<td>0.94</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>introductory material, description of methods and materials, and</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>discussion of results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Formats reports using consistent and logical headings.</td>
<td>0.97</td>
<td>0.83</td>
</tr>
<tr>
<td>7</td>
<td>Adequately prepares reader for analysis of results by conveying (1) what</td>
<td>0.82</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>was done in the experimental procedure, (2) why it was done, and, where</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>applicable, (3) what didn’t work.</td>
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<td></td>
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<tr>
<td>8</td>
<td>Presents results using graphics, mathematics, and/or prose.</td>
<td>0.97</td>
<td>0.94</td>
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<tr>
<td>9</td>
<td>Analyzes results and describes methods used in doing so.</td>
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<td>0.79</td>
</tr>
<tr>
<td>10</td>
<td>Identifies and quantitatively analyzes errors and uncertainties. This</td>
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<td>0.71</td>
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<tr>
<td></td>
<td>should include discussion of fitting parameters and their uncertainties.</td>
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<td>11</td>
<td>Uses tools for technical writing, including word-processing of</td>
<td>1.00</td>
<td>0.92</td>
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<td>mathematical equations and software-generated graphs.</td>
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<td>Consistently cites sources using APS or other professional journal style.</td>
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<td>0.94</td>
<td>0.58</td>
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</table>

2 Samples collected from PHYS 4052W, Spring 2011, N = 15
3 Samples collected from PHYS 4502W, Spring 2014, N = 12
Responses: Physics  
From RATING SESSION DEBRIEFING

At the conclusion of the rating session, raters completed an online survey. This survey asked for impressions of students’ writing strengths and weaknesses and reactions to criteria. In a brief debriefing discussion, these reactions were further discussed. What follows is drawn directly from the surveys and from transcriptions of the subsequent discussion.

1. Now that you’ve worked through a significant number of individual writing samples from a specific college/department, what patterns of strength and/or weakness did you notice?

**Strengths:**
- Sentence and paragraph cohesion (Writing Specialist only)
- Overall reporting of experiment results

**Weaknesses:**
- Figure captions
- Proper citation
- Abstracts – more than half unsure of purpose of abstract
- Conceptual problems in presentation of the science

2. Were any of the items on the rating guide difficult to interpret/use? If so, which were they? What sorts of questions did these items provoke?

**Criterion 1:** Seamlessly integrates physics concepts and mathematical equations into prose using comprehensive in-text reference, and in the case of equations, appropriate numbering protocol.
- This mixes high level (seamless integration) and low level (equation numbering) and that is confusing.

**Criterion 4:** Uses style based on that of scientific paper (containing abstract, introductory material, description of methods and materials, and discussion of results).
- There are often problems with certain sections (like abstracts) and it would be nice to flag the development of each separately.

**Criterion 7:** Presents results using graphics, mathematics, and/or prose.
- Is it enough to present it or does it have to be good? Do you mean presents results with effective, compelling, accurate graphics (probably should be its own criteria); with clear, well developed mathematics, and so on?

**Criterion 10:** Uses tools for technical writing, including word-processing of mathematical equations and software-generated graphs.
- Is it enough they didn’t draw by hand or do they need to be formatted correctly? How is this different from 7?

3. Did you find yourself wishing that you could address writing issues that were not contained in the rating guide? If so, what were they?

- Organization and structure – overall structure, paragraph structure, clarity, completeness
- Scientific accuracy
5-Minute Workshop: Abstract

This 5-minute workshop is designed to help you teach your students what information they should include in an abstract. The guide to writing lab reports included in the students' lab manual explicitly tells them this, but it is extremely terse. If the students are having trouble, use this to reiterate the concept.

Just as a reminder, we tell our students to include this information in their abstracts:

- the question they are trying to answer,
- the method they used to answer it, and
- their results.

**Goal**

Your goal will be to get the students to

- recall the three pieces of information they should include in their abstracts,
- identify the information missing from a sample abstract,
- identify superfluous information in the same sample abstract, and
- propose a revision of the sample abstract to add the missing and remove the superfluous information.

**Sample Work**

The sample work for this report is just an abstract. It is sample student work that has been slightly modified to make it more completely illustrate the point of an abstract.

This abstract includes a statement of the question (albeit one that could be improved by a phrase like "down an incline due to gravity") and a statement of the method. It does not include a statement of results. It includes a superfluous statement of motivation.

The sentences in this abstract are not particularly well-written, so let your students know that that isn't the point and that they should just let it slide and focus on the content of the sample.

**The Sample**

A neighbor's child wanted to know how to build a good soapbox derby car. The problem was to determine whether or not increasing an object's mass, in this case a toy car, would effect its acceleration. To accomplish this, the toy car was placed upon a ramp with an incline twice. Once without additional mass and once with an additional mass of 500g. The car was then release from rest while a video recorder recorded the motion and time of the car.

[Here](#) is a page with just the sample work for display to the students during the workshop.

**Execution**
Begin by telling the students that you are going to spend a few minutes talking about how to write an abstract; then, prompt them to offer up this information. Get them to say that the abstract should include the question, the method, the results, and not really anything else.

Once the students have brought up these things, present the sample work. Ask the students what is wrong with it, and once they answer, have them break up into groups and revise it for one to (at most) two minutes. Browse the room to watch for a group that has a good revision, and ask them to share it with the class once the editing time is over. (Hopefully there will be a lot of good revisions, but we don't have time to spend on a poor one that students might share if you don't cherry-pick.) Confirm that the revision is a good one and move on.

Highlight the difference between an abstract and an introduction.

Summarize by saying that the abstract is like the report in miniature, or is like a "preview" or "teaser" of the report, and by reiterating the three pieces of information that they should put in their abstracts.
Typesetting Mathematics

It is important that you typeset mathematics properly in technical writing. Writing is ultimately about communication, and mathematical notation was developed to communicate mathematics effectively. Even if one is very careful to be unambiguous, mathematics typed as normal text tends to be difficult to follow, as in this formula for the electric field due to a charge distribution:

\[
\mathbf{E}(\mathbf{r}) = \frac{1}{(4 \pi \varepsilon_0)} \int \rho(\mathbf{r}') (\mathbf{r} - \mathbf{r}')/|\mathbf{r} - \mathbf{r}'|^3 \, d^3r'
\]

This does not communicate effectively. To produce written mathematics that does communicate effectively, you need to use the mathematical typesetting capabilities of your desktop publishing software. This page will demonstrate how to typeset the above equation in LaTeX, LibreOffice, Google Docs, and Microsoft Word.

LaTeX

The standard desktop publishing software used in the physics community is TeX / LaTeX. Unlike the other software in this list, it is not a word processor. TeX is a markup language, like HTML. LaTeX is a set of macros for TeX. One produces a document using TeX / LaTeX by first writing markup in a text editor, then processing it using the TeX / LaTeX software. By default, there is no graphical interface. This may sound complicated, but it does have its advantages, and its output is better-looking (by far) than any of the other options in this list.

Unfortunately, TeX and LaTeX are too much to teach in this document, but there are lots of great resources online if this is appealing to you. Some recommendations for freely-available ones are the LaTeX wikibook, Tobias Oetiker's The Not-So-Short Introduction to LaTeX, and Scott Pakin's The Comprehensive LaTeX Symbol List. The classic text is Michael Spivak's The Joy of TeX, but this is not freely available.

That said, here is the LaTeX markup to produce a document containing only the equation for the electric field:

\begin{verbatim}
\documentclass{article}
\usepackage{amsmath,amssymb}
\begin{document}
\begin{equation*}
\vec{E} (\vec{r}) = \frac{1}{4 \pi \varepsilon_0} \int \rho (\vec{r}') \frac{(\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^2} \, d^3r'
\end{equation*}
\end{document}
\end{verbatim}

Here is the output:

\[
\vec{E}(\vec{r}') = \frac{1}{4\pi \varepsilon_0} \int \rho(\vec{r}') \frac{\vec{r} - \vec{r}'}{|\vec{r} - \vec{r}'|^3} \, d^3r'
\]
By using some explicit spacing commands, we can make it look even a little better. The biggest difference is probably the space before the primes for the vector indicating the point in the charge distribution:

\documentclass{article}
\usepackage{amsmath,amssymb}
\begin{document}
\begin{equation*}
\vec{E} \left( \vec{r} \right) = \frac{1}{4 \pi \epsilon_0} \int \rho \left( \vec{r}' \right) \frac{\vec{r} - \vec{r}'}{|\vec{r} - \vec{r}'|^2} \, d^3r'
\end{equation*}
\end{document}

That should at least give you an idea of how typesetting using TeX / LaTeX works. Check out those other resources mentioned above if you'd like to learn more.

TeX has been around for a long time (so has LaTeX, but not quite as long) and has strongly influenced how mathematics is typeset in general. All of the other software described in this document accepts input in syntax that is often similar to TeX syntax, or is TeX syntax outright. For the simple reason that most mathematical typesetting syntax is derived from TeX's, and so you'll have to learn at least a little of it pretty much no matter what choice of software you make, it is recommended that you learn at least a little TeX, eventually.

**LibreOffice**

Since LibreOffice is a graphical program, rather than simply tell you how to typeset an equation, I'm going to show you instead, in this video.

**Google Docs**

This video will show you how to typeset an equation in Google Docs.

**Microsoft Word**

This video will show you how to typeset an equation in Microsoft Word.
Appendix II: Sample Logbook for PHY 2605
Very large file - available as a [link](#)
APPENDIX III – Process for developing SPA First WEC Edition

Ways in which the School of Physics and Astronomy is unique, mentioned earlier, resulted in a procedure for composing a WEC Writing Plan somewhat different than that used by other participating Units to date. Front and center is the fact that James Flaten, the “Faculty Liaison” for Physics, is not in fact a Physics faculty member but rather an alumnus (Ph.D., 1997), currently working as a contract faculty member in another U of M department (Aerospace Engineering and Mechanics). This compromise was adopted because the School of Physics and Astronomy did not feel it could release a standard faculty member to accomplish this task. The agreement was that Flaten would work closely with School faculty, most notably Paul Crowell (Head of the Undergraduate Education Committee) and Cindy Cattell (Associate Head of Physics) to collect the necessary information from stakeholders, primarily School faculty and teaching assistants, to deliver an acceptable Writing Plan. After the Creation phase is complete, Cattell will oversee the implementation of the WEC Writing Plan, including direct supervision of the requested WEC mentor-TA.

The second major difference in procedure is that after a preliminary all-faculty meeting to discuss WEC survey results, held on Nov. 1, 2010, the faculty agreed that subsequent discussion of WEC issues and drafting of the Writing Plan would be done primarily by the individuals mentioned above, assisted by current instructors of the upper-level classes for majors that will be most-impacted (Prisca Cushman for PHYS 2605 and Jeremy Mans for PHYS 4051/4052W) plus an ad hoc group of additional interested faculty (Chuck Campbell, Dan Cronin-Hennessy, Tom Walsh) as well as the current mentor-TA most likely to become the WEC mentor-TA for next year (Allan Straub). Will Durfee from Mechanical Engineering was also consulted because of his familiarity with the WEC process, as implemented in his own department. Input was collected from faculty through brief email surveys when the individuals mentioned above did not feel they had adequate or complete knowledge of certain issues, such as the amount of writing done in certain upper level classes in the department.

Between November 2010 and April 2011, Flaten held a series of meetings with WEC staff as well as with Crowell and Cattell who, in turn, held additional discussions with the ad hoc group members and other faculty. The ad hoc group met in person with Flaten (and Pamela Flash and Angela Sprunger from WEC), on February 28, 2011, to discuss their progress and to clarify certain issues regarding the layout of the Writing Plan itself. From February to April of 2011, Straub held several, informal meetings with WEC, Physics, and Writing Studies faculty and staff. Ratings for the Desired Writing Abilities, and other key issues, were discussed in several meetings during the week of April 4, one of which brought together multiple stakeholders – Flaten, Flash and Mitch Ogden from WEC, Cattell and mentor-TA Allan Straub from Physics.

All-faculty meetings in the School of Physics and Astronomy often have oversubscribed agendas, which was partly why the School did not elect to conduct the “standard” four all-faculty meetings to discuss WEC issues. A brief update about the WEC plan was offered at an all-faculty meeting on March 28, 2011, followed by circulation of a draft of the Writing Plan and a more extensive discussion of the details of the plan and one more opportunity to provide feedback at an all-faculty meeting on April 11, 2011. Details about the Writing Plan were also circulated to departmental TAs to solicit their feedback. After addressing issues that arose, a final draft of the Writing Plan was circulated to departmental faculty on April 18, 2011, and the plan was adopted by an email vote on April 22, 2011.
V. WEC Research Assistant (RA) Request Form

This form is required if RA funding is requested. If no RA funding is requested please check the box below.

☐ No RA Funding Requested

RAs assist faculty liaisons in the WEC Writing Plan implementation process. The specific duties of the RA are determined in coordination with the unit liaison and the WEC consultant, but should generally meet the following criteria: they are manageable in the time allotted, they are sufficient to their funding, and they have concrete goals and expectations (see below).

RA funding requests are made by appointment percent time (e.g., 25% FTE, 10% FTE, etc.). Appointment times can be split between two or more RAs when applicable (e.g., two 12.5% appointments for a total of 25% FTE request). Total funds (including fringe benefits when applicable) need to be calculated in advance by the liaison, usually in coordination with administrative personnel¹.

Please note that, outside of duties determined by the liaison, WEC RAs may be required to participate in specific WEC activities, such as meetings, Moodle discussion boards, and surveys.

RA Name (Use TBD for vacancies): Julie Vievering
RA Contact Information: email jtvievering@gmail.com, phone 612-3011467
Period of appointment (Semester/Year to Semester/Year): F15 to Sp16
RA appointment percent time: F15: 50% Sp16: 75%

Define in detail the tasks that the RA will be completing within the funding period:
See pages 17-18 of this plan.

Define deadlines as applicable (please note that all deadlines must be completed within the funding period):
See pages 16-19 of this plan.

Describe how frequently the RA will check in with the liaison:
There will be formal bi-monthly check-ins and informal weekly check-ins.

Describe in detail the RA’s check-in process (e.g., via email, phone, in-person, etc.):
Formal check-ins will be in person; a google folder will also be shared between the liaison and RA as well as other relevant faculty and staff working on the WEC plan to share documents as they are developed.

¹ An example for determining funding for appointments can be found on the WEC Liaison Moodle. This is for planning and example purposes only and cannot be used to determine final budget items for the Writing Plan.
VI. WEC Writing Plan Requests

Unit Name: School of

Financial Requests (requests cannot include faculty salary support) drop-down choices will a,

Total Financial Request: $24,187.00

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate Student Salary</td>
<td>$4,698.00</td>
<td>Graduate Student Salary</td>
<td>$6,975.00</td>
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<tr>
<td>Graduate Student Fringe</td>
<td>$4,448.00</td>
<td>Graduate Student Fringe</td>
<td>$6,605.00</td>
</tr>
<tr>
<td>Enterprise Tax</td>
<td>$82.00</td>
<td>Enterprise Tax</td>
<td>$122.00</td>
</tr>
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</table>

semester 1 Total: $9,228.00  
semester 2 Total: $13,702.00

Rationale for costs and their schedule of distribution

Fall Semester - 10 hours per week at $23.97/hr. 19.6 weeks.  Spring Semester - 15 hours per week. 19.4 weeks. Benefits Fall and Spring - 17.6% + tuition at $18.48/hr. Summer 17.6%, no tuition. Enterprise tax 1.75% of the total.

Service Requests drop-down choices will appear when a cell in the "service" column is selected

<table>
<thead>
<tr>
<th>Service</th>
<th>Qty</th>
<th>Service</th>
<th>Qty</th>
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</thead>
<tbody>
<tr>
<td>Workshop</td>
<td>1</td>
<td>Workshop</td>
<td>2</td>
</tr>
<tr>
<td>Consultation</td>
<td>2</td>
<td>Consultation</td>
<td>2</td>
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</tbody>
</table>

Description and rationale for services

Odd semesters: 1 Workshop for TA orientation; Even semesters: 1 Workshop for Best Practices for Teaching in peer review with Faculty/TA; Consultations: developing, implementing and interpreting grading practices for long-term sustainability of WEC in physics and longitudinal comparisons; develop plan for sharing physics.
### Semester 3: Summer 2016

<table>
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<tr>
<td>Graduate Student Salary</td>
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<td>Graduate Student Fringe</td>
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</tr>
<tr>
<td>Enterprise Tax</td>
<td>$17.00</td>
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</tbody>
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Semester 3 Total: $1,257.00

### Semester 4:

| Item                | Cost  |

Semester 4 Total: $0.00

---

**Physics and Astronomy**

During Seminar. Semester 2: 1 workshop for best
rubrics and associated data; investigate best sharing goals with other WEC units requiring intro
<table>
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Semester 5 Total: $0.00  Semester 6 Total: $0.00

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<th>Service</th>
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<th>Service</th>
<th>Qty</th>
</tr>
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<tbody>
<tr>
<td>Workshop</td>
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<td>Workshop</td>
<td>1</td>
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<tr>
<td>Consultation</td>
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<td>Consultation</td>
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<th>Service</th>
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July 23, 2015

To: Lucy Fortson, Physics
From: Robert McMaster, Office of Undergraduate Education
Subject: Decision regarding WEC funding proposal

The Department of Physics recently requested the following funding to support its Writing Enriched Curriculum:

<table>
<thead>
<tr>
<th></th>
<th>Graduate Student Salary</th>
<th>Grad Student Fringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2015</td>
<td>$4,780.00</td>
<td></td>
</tr>
<tr>
<td>Fall 2015</td>
<td>$4,448.00</td>
<td></td>
</tr>
<tr>
<td>Spring 2016</td>
<td>$7,097.00</td>
<td></td>
</tr>
<tr>
<td>Spring 2016</td>
<td>$6,605.00</td>
<td></td>
</tr>
<tr>
<td>Summer 2016</td>
<td>$976.00</td>
<td></td>
</tr>
<tr>
<td>Summer 2016</td>
<td>$281.00</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$24,187.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

All items above have been approved by the Office of Undergraduate Education, for a total of $24,187.

Please provide Pat Ferrian (ferri004@umn.edu) with your department’s EFS information within 30 days of the receipt of this letter so the funds may be transferred.

CC: Suzanne Bardouche, Molly Bendzick, Dan Emery, Pat Ferrian, Pamela Flash, Sarah Hobbie, Ginny Olson, Ron Poling, Leslie Schiff