Standards Feedback Report

June 13, 2008

Introduction

This report, prepared for the South Carolina Commission on Higher Education by the Educational Policy Improvement Center (EPIC), provides a final list of recommended college readiness reference standards to be used as part of the South Carolina Course Alignment Project (SCCAP). The purpose of these standards is to serve as a common reference point for the development of courses in English/language arts, math, and science that align between high school and college. The standards are not designed as a substitute for existing South Carolina curriculum standards, nor are they related in any way to admission to postsecondary education in the state. They will be used as a reference point by design teams that will construct the aligned courses.

The standards were identified through a process managed by EPIC staff. First, consultants who were high school and college instructors trained in the development of college readiness standards reviewed the South Carolina Curriculum Standards and selected the standards that corresponded most closely with college readiness standards. Next, the consultants added standards from the Knowledge and Skills for University Success (KSUS) , a nationally recognized set of college readiness standards that represent a comprehensive statement of what university faculty expect in well-prepared students. Finally, cross-disciplinary key cognitive and foundational skills derived from the Texas College Readiness Standards were also included.

This draft list of college readiness reference standards was submitted to the South Carolina Commission on Higher Education, the SCCAP Steering Committee, and to additional faculty and administrators from South Carolina educational institutions, who were asked to review and comment on them. The review was completed via a web application in which each participant selected one or more of the four subject areas and the cross-disciplinary skills to review. In each subject area, respondents could agree or disagree with the inclusion of a standard and enter a comment. A total of 104 participants submitted 118 reviews (see Table 1).

The standards recommended in this report are based on the feedback received from these reviews.

Table 1. Number of submissions by subject area

Subject	Number of Submissions
Cross-Discipline	10
English/language arts	37
Mathematics	34
Science	37
Total Submissions	**118**

Four participants submitted responses to two of the four subject areas, while two participants each submitted responses for three and four subject areas. The other 96 participants submitted responses for one subject area.

Table 2 lists participation in the standards review by institutional affiliation.

Table 2. Number of participants by institutional affiliation

Institutional Affiliation	Number of Participants
Higher education 2-year administrator	11
Higher education 2-year faculty member	55
Higher education 4-year administrator	1
Higher education 4-year faculty member	30
K-12 administrator	3
K-12 faculty member	4
Total Participants	**104**

The standards identified through this review process will serve as the reference point for the South Carolina Course Alignment Project, and although the results of the standards review are not generalizable beyond this project, they will be sufficient for the development of paired courses. During the next phase of the project, Design Teams will be convened to develop paired courses. The Design Teams will be able to examine and refine these standards as part of the development process.

The standards for each subject area, with the comments collected by the online tool, are listed in the following sections of this report. Over 300 comments were received; these comments are listed in the column to the right of the standards. Please note that the “Comments” column contain the actual verbatim comments received. For each subject area, standards with more than 80% agreement (based on participants who entered a response to the “agree” or “disagree” options) are recommended for inclusion. Those that fall below the criterion cut point of 80% are indicated by tan highlighting in the applicable rows. The text at the beginning of each subject area section summarizes the total number of standards being recommended for deletion from the original draft list of standards.

Cross-Disciplinary Standards

This section comprises 45 standards. No standards were recommended for deletion because overall agreement level was high. However, the participation rate was low; only ten participants provided responses.

Key Cognitive Skills	Comments
A. Intellectual curiosity	
1. Engage in scholarly inquiry and dialogue.	
2. Accept constructive criticism and revise personal views when valid evidence warrants.	Most students do not arrive at college with the ability to accept constructive criticism or the ability to revise their own views; #2 is especially important, especially when it concerns the student's writing. If a student cannot accept constructive criticism from an instructor, that student is virtually unteachable in a composition class or other class that requires substantial amounts of writing.

B. Reasoning	
1. Consider arguments and conclusions of self and others.	
2. Construct well-reasoned arguments to explain phenomena, validate conjectures, or support positions.	They are not intellectually sophisticated enough to do this; Students need to be ready to do tasks 2-4; they do not necessarily need to be accomplished in these areas as long as they are prepared to do them.
3. Gather evidence to support arguments, findings, or lines of reasoning.	
4. Support or modify claims based on the results of an inquiry.	They can support their claims because they select only info that does support them. They rarely include info that forces them to modify their claims. We work significantly on these issues in required introductory courses in "The Human Experience" and critical thinking.

C. Problem solving	
1. Analyze a situation to identify a problem to be solved.	
2. Develop and apply multiple strategies to solving a problem.	There should be some wording about using the team approach to problem solving. More and more companies are taking the team approach to solving problems. Doctors and lawyers both collaborate within their professions when the problem is to big for one person to handle.
3. Collect evidence and data systematically and directly relate to solving a problem.	Again, students need to be ready to do task 3, not accomplished in this area.

D. Academic behaviors	
1. Self-monitor learning needs and seek assistance when needed.	These behaviors are extremely important! If students are in the habit of doing these things, they can overcome many other deficiencies.
2. Employ study habits necessary to manage academic pursuits and requirements.	For #2-4, students come to college studying fewer than 6 hours a week—according to information that they furnish us. They believe initially that they can succeed in college doing the same. They are anxious to complete a task, but not necessarily master it.
3. Strive for accuracy and precision.	
4. Persevere to complete and master tasks.	

E. Work habits	
1. Work independently.	
2. Work collaboratively.	

F. Academic integrity	
1. Attribute ideas and information to source materials and people.	
2. Evaluate sources for quality of content, validity, credibility, and relevance.	Only on a basic level.
3. Include the ideas of others and the complexities of the debate, issue, or problem.	
4. Adhere to ethical codes of conduct.	Particularly essential. We can teach students to do the other 3, but unless they understand the importance of academic integrity, they are not likely to follow through adequately and avoid plagiarism problems.

Foundational Skills	Comments
A. Reading across the curriculum	All are essential; They do not know how to do these things when they come to us.
1. Employ effective prereading strategies.	
2. Apply a variety of strategies to understand the meanings of new words.	
3. Identify the intended purpose and audience of the text.	
4. Identify the key information and supporting details.	
5. Analyze textual information critically.	
6. Annotate, summarize, paraphrase, and outline texts when appropriate.	
7. Adapt reading strategies according to structure of texts.	
8. Connect reading to historical and current events and personal interest.	

B. Writing across the curriculum	
1. Write clearly and coherently using standard writing conventions.	
2. Write in a variety of forms for various audiences and purposes.	
3. Compose and revise drafts.	

C. Research across the curriculum	
1. Identify which topics or questions are to be investigated.	On items 1-3, we expect a basic ability in these areas, but we expect to teach 4-8.
2. Explore a research topic.	
3. Refine research topic based on preliminary research and devise a timeline for completing work.	
4. Evaluate the validity and reliability of sources.	They have not developed this skill when they arrive.
5. Synthesize and organize information effectively.	
6. Design and present an effective product.	
7. Integrate source material.	
8. Present final product.	

D. Use of data	
1. Identify patterns or departures from patterns among data.	
2. Employ statistical and probabilistic skills necessary for planning an investigation, and collecting, analyzing, and interpreting data.	We certainly would like a very basic skill level, but we don't expect sophistication in this area. Don't have the sophistication to do these things when they arrive at college.
3. Present analyzed data and communicate findings in a variety of formats.	

E. Technology	We are finding that students are quite sophisticated in employing technology for entertainment or personal communication; however, they lack many skills in using technology as an academic tool, including communicating with faculty.
1. Employ technology to gather information.	
2. Employ technology to organize, manage, and analyze information.	
3. Employ technology to communicate and display findings in a clear and coherent manner.	
4. Employ technology appropriately.	

English/Language Arts Standards

Thirty-seven participants submitted reviews of the English/language arts standards with a 93% level of agreement. Four standards did not reach the 80% criterion for inclusion (*indicated by gray highlighting*). Those four standards are in the Reading Literature section. Respondents indicated that the rigor of these standards is beyond the entry-level college expectation level.

Standards	Comments
A. Reading Literature	There's a lot of overlap in these objectives, creating what are duplicative and/or ambiguous distinctions between standards. If that's intentional, ok. But if not, some condensation seems desirable to add both clarity and simplicity – without sacrificing substance. Examples: #5 and #7 are different dimensions of the same ability, as are #8/9/10. It may be that there's a good reason of which I'm not aware to integrate that kind of overlap, and if so, disregard this observation. The College Readiness Standards with which I disagree are far too detailed, nuanced, or advanced for students merely preparing for college. That is, these are areas where I would expect college level classes to improve skill sets and student abilities. The information that a student has "at hand" and can easily recall is not nearly important as general critical thinking skills applicable to almost all fields of study. In my dreams students could do all I agreed with [below], but I've yet to meet a college student who could actually do so. I especially think that identifying archetypes, such as universal destruction, journeys, tests, and banishment, that appear across a variety of types of literature, including American literature, world literature, myths, propaganda, and religious texts, is beyond most of my college's students. SHOULD students be able to do this? In my dreams.

	I would love it if all our college students came with all of this knowledge and these skills! They would certainly be well-prepared. However, I've found that it's more important that students have skills that allow them to read literature than specific knowledge about literature (thus, I've checked disagree on several items – these are items we generally try to teach by expanding on the basic interpretive skills contained in other items). I am also concerned about the degree to which students should be able to perform the skills. There are so many levels of performance, and I'm not sure how to specify the appropriate levels on this type of list.
1. Read, comprehend, and be able to discuss a variety of literary texts in print AND nonprint formats.	I believe it is necessary for an entering college freshman to at least have a basic knowledge of literary terminology and an understanding of the complexities that make up a literary work's context. This way the student has a foundation to build more specific analysis upon and is more likely to grasp the significance of what he/she continues to learn about literature.
2. Engage in an analytic process to enhance comprehension and create personal meaning when reading text. This includes the ability to annotate, question, agree or disagree, summarize, critique, and formulate a personal response.	
3. Make supported inferences and draw conclusions based on textual features, seeking such evidence in text, format, language use, expository structures, and arguments used.	

4. Explain plot and character development in literature, including character motive, causes for actions, and the credibility of events.	On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.
5. Apply aesthetic qualities of style, such as diction or mood (for example), as a basis to evaluate literature that contains ambiguities, subtleties, or contradictions.	On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.
6. Identify basic beliefs, perspectives, and philosophical assumptions underlying an author's work. This includes identifying points of view, attitudes, and the values conveyed by specific use of language.	
7. Discuss with understanding the effects of an author's style and use of literary devices to influence the reader and evoke emotions. This includes but is not limited to such devices as imagery, characterization, choice of narrator, use of sound, formal and informal language, allusions, symbols, irony, voice, flashbacks, foreshadowing, time and sequence, and mood.	
8. Engage in an analytic process that enables students to make connections between different texts, including comparing and contrasting formal and thematic aspects.	However, I've found that it's more important that students have skills that allow them to read literature than specific knowledge about literature (thus, I've checked disagree on several items – these are items we generally try to teach by expanding on the basic interpretive skills contained in other items).

9. Identify archetypes, such as universal destruction, journeys, tests, and banishment, that appear across a variety of types of literature, including American literature, world literature, myths, propaganda, and religious texts.	
10. Discuss with understanding themes such as initiation, love and duty, heroism, and death and rebirth that appear across a variety of literary works and genres.	These are skills necessary for an English major – not for all high school students. Many 2-year students do not take courses which require the level of knowledge suggested here. In 2-year colleges students are far more likely to focus on nonfiction texts. These standards are the designer's wishful thinking if the teachers are preparing students for the "real" world. Many of the other skills are necessary only at a minimal level.
11. Apply reading skills and strategies to understand a variety of types of literature, for example, epic pieces (such as the Iliad), lyric poems, novels and other longer narratives, and philosophical pieces.	
12. Summarize the salient characteristics of major types and genres of texts, including but not limited to novels, short stories, horror stories, science fiction, biographies, autobiographies, poems, and plays.	However, I've found that it's more important that students have skills that allow them to read literature than specific knowledge about literature (thus, I've checked disagree on several items – these are items we generally try to teach by expanding on the basic interpretive skills contained in other items). On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.

13. Explain the formal constraints of different types of texts and distinguish between, for example, a Shakespearean sonnet and a poem written in free verse.	On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.
14. Demonstrate familiarity with major literary periods of English and American literature and their characteristic forms, subjects, authors, and major works.	Numbers 14, 15, 18, and 19 are things I would expect a student to learn during the first year or two of college; they are not things I would expect a high-school graduate to know. However, I've found that it's more important that students have skills that allow them to read literature than specific knowledge about literature (thus, I've checked disagree on several items – these are items we generally try to teach by expanding on the basic interpretive skills contained in other items). 14, 15, 16, and 19. These skills are generally learned in 200-level college English classes and are not something that a student should necessarily be able to do as part of "college readiness."
15. Demonstrate familiarity with authors from literary traditions beyond the English-speaking world.	
16. Discuss with understanding the relationships between literature and its historical and social contexts.	

17. Summarize major historical events that may be encountered in literature.	However, I've found that it's more important that students have skills that allow them to read literature than specific knowledge about literature (thus, I've checked disagree on several items – these are items we generally try to teach by expanding on the basic interpretive skills contained in other items). On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.
18. Demonstrate familiarity with the concept of the relativity of all historical perspectives, including their own.	However, I've found that it's more important that students have skills that allow them to read literature than specific knowledge about literature (thus, I've checked disagree on several items – these are items we generally try to teach by expanding on the basic interpretive skills contained in other items). On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years. The level of familiarity of historical perspective may not be met. This is not part of the SC standards in either Social Studies or English. Historical context would be expected, but not perspective. I am truly not sure what is meant by this standard.
19. Discuss with understanding the relationships between literature and politics, including the political assumptions underlying an author's work and the impact of literature on political movements and events.	On questions when "Disagree" is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.

20. Employ a variety of strategies to understand the origins and meanings of new words, including analysis of word roots and the determination of word derivations, with an emphasis on the importance of Greek and Latin roots and affixes.	On questions when “Disagree” is the answer, my response is based on the fact that many of our college students have not mastered these particular skills until their junior or senior years.
21. Recognize and comprehend narrative terminology and techniques, such as (for example) author versus narrator, stated versus implied author, and historical versus present-day reader.	
22. Employ monitoring and self-correction, as well as reading aloud, as means to ensure comprehension.	
23. Carry out independent reading for extended periods of time to derive pleasure.	

B. Reading Informational Texts	As above, there seems to be substantive redundancy in some standards for this section – e.g., #4 and #8 are evaluating essentially the same skill (detecting bias and inferring motive) #2/6/7/9/10 survey different dimensions or applications of the same basic skill (comprehension of objective information) #13-15 are variations on standard expressed in #1 and #7 #11-12 are variations on standard expressed in #9. Again, if there are compelling reasons for this redundancy, then disregard these comments.

	I think that it is interesting that the skills most adults use are the ones least required in public schools. There are 15 standards for reading informational text while 23 for reading literary texts. That seems backwards. The majority of adults do not read literature – and especially not to the extent implied in the standards.
1. Read and comprehend a variety of informational texts in print and nonprint formats.	We work on this aspect in college. Students also need to be taught how to create informational texts using appropriate visual elements with the use of common software packages like Microsoft Word and Excel.
2. Compare, contrast, and evaluate theses within and across informational texts.	
3. Compare, contrast, and evaluate information within and across texts to draw conclusions and make inferences.	
4. Analyze informational texts for indicators of author bias such as word choice, the exclusion and inclusion of particular information, and unsupported opinion.	Numbers 4, 6, and 8 involve skills that are more subtle than simple comprehension. I would not expect many 18-year-olds to know how to identify and analyze bias and propaganda. Most 40-year-olds can't do those things.
5. Carry out independent reading for extended periods of time to gain information.	
6. Analyze the impact that text elements have on the meaning of a given informational text.	
7. Analyze information from graphic features such as charts and graphs in informational texts.	

8. Analyze and evaluate informational texts to identify propaganda techniques.	
9. Apply reading skills and strategies to understand informational texts.	
10. Comprehend informational writing or instructions in software or software documentation, job descriptions, college applications, historical documents, government publications, newspapers, essays, and textbooks.	Too broad to have much meaning. Some historical documents, government publications, and essays are easy to understand; others require superior reading skills and considerable knowledge. As it's written, the question can't be answered.
11. Comprehend and apply vocabulary and content, including subject area terminology; connotative and denotative meanings; and idiomatic meanings.	
12. Exercise a variety of strategies to understand the origins and meanings of new words, including recognition of cognates and contextual clues	
13. Read and interpret visual images, including charts and graphs.	
14. Identify the primary elements of the types of charts, graphs, and visual media that occur most commonly in texts.	
15. Interpret accurately the content of charts, graphs, and visual media that occur in texts.	

C. Writing And Self-Expression	Again, we work on these in college. Evidence indicates that students do not have these skills when they arrive. It would be nice if they did, but we spend much time addressing these issues.
1. Apply writing conventions to write clearly and coherently and write for a variety of purposes and audiences.	I certainly believe that students must be familiar with a number of different writing modes, but I also think that a detailed understanding of argument and persuasion should probably be reserved for college level classes. I would not expect students to enter my English 101 class with a deep understanding of argumentative rhetoric. Entering freshman need to have a much stronger background in grammar than they currently do. Understanding grammar is critical to effective reading and writing. Without having power over grammar, students are less likely to make smart choices and/or have the confidence to make smart choices in their writing. Also, entering freshman should have a much better understanding of how to fully develop a point. 1st year college students often have a basic understanding about writing; they need their college level writing classes to teach them more about content in a piece of writing and to be able to identify and improve upon their style.
2. Apply several pre-writing strategies, including developing a focus; determining the purpose; planning a sequence of ideas; using structured overviews; and creating graphic organizers, models, and outlines.	Numbers 2, 7, 9, 10, and 18 come through experience, if at all. I don't expect a recent high-school graduate to have written enough to have developed a voice or style. Nor do I expect a typical 18- or 19-year-old to understand how to develop a good argument.

3. Employ a variety of complete sentence structures appropriately in writing, including compound, complex, compound-complex, parallel, repetitive, and analogous sentence structures.	
4. Apply paragraph structure in writing as manifested by the ability to construct coherent paragraphs and arrange paragraphs in logical order.	
5. Present ideas to achieve overall coherence and logical flow in writing and employ appropriate techniques such as transitions and repetition to maximize cohesion.	
6. Apply words correctly; apply words that mean what the writer intends to say; and employ a varied vocabulary.	
7. Demonstrate development of a controlled yet unique style and voice in writing where appropriate.	
8. Apply proofreading skills to edit for the correct use of written Standard American English.	
9. Apply a variety of methods to develop arguments, including compare-contrast reasoning; logical arguments (inductive-deductive); and alternation between general and specific (e.g., connections between public knowledge and personal observation and experience).	Most freshmen composition classes focus on development of rhetorical modes, especially argumentation/persuasion. Therefore, the skills in 9 and 10 are taught on the college level and should not be considered part of "college readiness."

10. Write to persuade the reader by anticipating and addressing counterarguments, by using rhetorical devices, and by developing an accurate and expressive style of communication that moves beyond mechanics to add flair and elegance to writing.	
11. Apply revision strategies to improve the organization and development of content and the quality of voice in written works. These strategies include: reviewing ideas and structure in substantive ways to improve depth of information and logic of organization; reassessing the appropriateness of writing in light of genre, purpose, and audience; and using feedback from others to revise written work.	While it would be wonderful if students came to college with solid revision strategies, these skills are taught in ENG 101 because the students do not know how to revise--most students feel one draft of a paper is sufficient.
12. Create informational pieces such as letters of request, inquiry, or complaint that use language appropriate for the specific audience.	12, 15, 17, and 18 all tie to business writing. These skills are not truly college readiness skills.
13. Create narratives such as personal essays, memoirs, or narrative poems that use descriptive language to create tone and mood.	#13 and #19 are almost redundant.
14. Create descriptions for use in other modes of written works such as narratives and expository or persuasive pieces.	

15. Produce clear and concise career-oriented/technical writings such as memos, business letters, résumés, technical reports, and information analyses.	
16. Create narratives such as personal essays, memoirs, and narrative poems that use descriptive language to enhance setting and characterization.	This is a rare skill that comes through extensive reading, a lot of writing, and a lot of criticism of one's writing. I'd expect perhaps 1 college graduate in 100 to have the skill described in number 16.
17. Create persuasive writings such as editorials, essays, speeches, or reports that address a specific audience and support a clearly stated thesis with facts, statistics, and/or first-hand accounts, among other forms.	
18. Create persuasive writings such as editorials, essays, speeches, or reports that address a specific audience and employ logical arguments supported by facts or expert opinions.	
19. Create narratives such as personal essays, memoirs, and narrative poems that use descriptive language to enhance voice and tone.	
20. Create responses to literary texts through a variety of methods in addition to writing, such as oral presentations, media productions, and the visual and performing arts, among other forms.	#20 and #21 could be combined to refer to texts in general.

21. Create responses to informational texts through a variety of methods such as drawings, written works, oral presentations, and media productions, among other forms.	

D. Research And Information Technology	
1. Pursue research projects and make use of appropriate technologies in both research and writing.	Simply using technology is not a problem for most high school student; using it wisely is the bigger problem.
2. Design and carry out research projects by selecting a topic, constructing inquiry questions, accessing resources, and organizing information.	We teach many of these skills in college English courses; however, we do expect students to have a basic understanding that we can build on.
3. Employ a variety of print or electronic primary and secondary sources including books, magazines, newspapers, journals, periodicals, and the Internet.	
4. Select relevant sources when writing research papers and appropriately include information from such sources; logically introduce and incorporate quotations; synthesize information in a logical sequence; identify different perspectives; identify complexities and discrepancies in information; and offer support for conclusions.	Many students have not yet mastered the skills addressed in "Disagree" answers; however, they work on this mastery in college. Ideally, we would like for them to have all these skills, but they seem to struggle with and address these deficiencies as they progress through their college curriculum.;

5. Evaluate sources of information located on the Internet in particular to ascertain their credibility, origin, potential bias, and overall quality.	Many students have not yet mastered the skills addressed in "Disagree" answers; however, they work on this mastery in college. Ideally, we would like for them to have all these skills, but they seem to struggle with and address these deficiencies as they progress through their college curriculum. My hope is that more entering freshman will have had exposure to online library resources and will have learned how to evaluate an internet source for credibility.
6. Employ direct quotations, paraphrasing, or summaries to incorporate into oral or written works the information gathered from a variety of research sources.	Many students have not yet mastered the skills addressed in "Disagree" answers; however, they work on this mastery in college. Ideally, we would like for them to have all these skills, but they seem to struggle with and address these deficiencies as they progress through their college curriculum.
7. Comprehend the concept of plagiarism and how (or why) to avoid it and apply rules for paraphrasing, summarizing, and quoting, as well as conventions for incorporating information from Internet-based sources in particular.	While we expect students to come to college knowing how to document papers and avoid plagiarism, too often students tell us that they have either never written a research paper or never been required to document sources. High schools are doing a disservice to students if they do not focus on appropriately incorporating research materials and avoiding plagiarism.
8. Apply a standardized system of documentation (including a list of sources with full publication information and the use of in-text citations) to properly credit the work of others.	
9. Create written works and oral and visual presentations that are designed for a specific audience and purpose.	
10. Select appropriate graphics, in print or electronic form, to support written works and oral and visual presentations.	

11. Apply the spell-checker and grammar check function in word processing software while understanding the limitations of relying upon these tools.	

Science Standards

The science standards include standards for biology, chemistry, physics, physical science, and earth science. Thirty-seven participants submitted reviews of the science standards. Twenty-nine standards received less than 80 percent agreement, the criterion level for recommended inclusion (*indicated by gray highlighting*).

Table 3. Number of standards by science subject area

Subject Area	Delete	Total Standards
Biology	1	47
Chemistry	20	59
Physics	7	71
Physical Science	1	54
Earth Science	0	55
Total Standards	**29**	**286**

Biology Standards	Comments
A. Demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.	Sophistication is hard for some of these in a biological context, they need to be appropriate to resources and developmental abilities. I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. I would be happy if all of our college graduates could do these! Students should be proficient at a beginner level. We should not expect them to be experts at scientific design when they graduate from high school. Similarly, the equipment, measurement, and analysis that we would expect them to use correctly should be simple, beginner-level. It is important to set achievable goals for these students so that they may experience the joy that comes with success. Science should be fun, not daunting.

1. Generate hypotheses (with testable and falsifiable predictions) based on credible, accurate, and relevant sources of scientific information.	I would add wording to items 1 and/or 7 regarding appropriate use of and proper citation for all literature/references used in the investigation.
2. Employ appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.	Although I am in agreement with each of these standards, it has been my experience that numbers 2 and 3 are not necessary for incoming freshmen. Apparatus available is dissimilar among schools and colleges - there is no "standard" set of instrumentation that is present and functioning in ALL schools and ALL universities/colleges.
3. Employ scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.	
4. Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations.	
5. Organize and interpret the data from a controlled scientific investigation by using mathematics, graphs, models, and/or technology.	
6. Evaluate the results of a controlled scientific investigation in terms of whether or not they support hypothesis.	
7. Present results of investigations and seek critique from others.	
8. Apply appropriate safety procedures when conducting investigations.	

9. Debate complex issues arising from the application of science and technology in society.	I do not think this is a readiness issue, but a learned skill on the college level. If students were able to debate complex issues right out of high school, then what will they learn in college? I agree that students should be able to debate issues but my concern is whether the students understand enough of the science and the technology to have an "intelligent debate". Furthermore, what is considered and example of a "complex issue" at this level? Stem cell research is a topic that comes to my mind, for example but one that can have many levels of complexity.
[Suggested additional standard]	I would add another statement. Students must be able to contrast the terms hypothesis, theory, and law. Most freshman have no concept of what a scientific theory entails. K-12 educators seem to instill in students that a hypothesis becomes a theory which becomes a law (which is impossible).

B. Demonstrate an understanding of the structure and function of cells and their organelles.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous.; Again I would like to stress that students need only be proficient at a beginner level. Some of the objectives listed have the potential to bog down the high school student if too much detail is required. Leave us something to teach them in Introductory Biology!
1. Recall the three major tenets of cell theory (all living things are composed of one or more cells; cells are the basic units of structure and function in living things; and all presently existing cells arose from previously existing cells).	

2. Summarize the structures and functions of organelles found in a eukaryotic cell (including the nucleus, mitochondria, chloroplasts, lysosomes, vacuoles, ribosomes, endoplasmic reticulum [ER], Golgi apparatus, cilia, flagella, cell membrane, nuclear membrane, cell wall, and cytoplasm).	
3. Compare the structures and organelles of prokaryotic and eukaryotic cells.	
4. Explain the process of cell differentiation as the basis for the hierarchical organization of organisms (including cells, tissues, organs, and organ systems).	
5. Explain how active, passive, and facilitated transport serve to maintain the homeostasis of the cell.	
6. Summarize the characteristics of the cell cycle: interphase (called G1, S, G2); the phases of mitosis (called prophase, metaphase, anaphase, and telophase); and plant and animal cytokinesis.	
7. Summarize how cell regulation controls and coordinates cell growth and division and allows cells to respond to the environment, and recognize the consequences of uncontrolled cell division.	I have found it difficult for students in a general Biology or even an upper level Bio course such as Microbiology to be able to understand the concept of gene regulation and expression. I feel this item is at a higher level of difficulty than the other items listed in this section.
8. Explain the factors that affect the rates of biochemical reactions (including pH, temperature, and the role of enzymes as catalysts).	

C. Demonstrate an understanding of the flow of energy within and between living systems.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. The major outcome statement is too broad. I would suggest subdividing the statement into two separate statements. The first would consider energy production at the cellular level. The second would consider the flow of energy between living systems. Only one subservient outcome (#6) considers the flow of energy between systems, and this statement has an enormous amount of material lumped into one statement.
1. Summarize the overall process by which photosynthesis converts solar energy into chemical energy and interpret the chemical equation for the process.	1 & 2 Shouldn't these items include something about the pathways involved such as glycolysis, krebs cycle, electron transport chain, chemiosmosis, and fermentation. In my opinion, it is important for the students to be aware that these equations are just the summary of a very complex process.
2. Summarize the basic aerobic and anaerobic processes of cellular respiration and interpret the chemical equation for cellular respiration.	
3. Recognize the overall structure of adenosine triphosphate (ATP)—namely, adenine, the sugar ribose, and three phosphate groups—and summarize its function (including the ATP-ADP [adenosine diphosphate] cycle).	Not sure what value can be obtained from asking a HS student to understand structure-function relationships, though I admit if they can they're ready for college!
4. Summarize how the structures of organic molecules (including proteins, carbohydrates, and fats) are related to their relative caloric values.	
5. Summarize the functions of proteins, carbohydrates, and fats in the human body.	Add nucleic acids.

6. Illustrate the flow of energy through ecosystems (including food chains, food webs, energy pyramids, number pyramids, and biomass pyramids).	Too complicated for entry-level student. More appropriate for ecology or environmental science course. Teacher misconceptions in this content area are too great to expect students to understand the nuances between energy flow and energy capture and subsequent inefficient transfer of that energy following tenets of the second law of thermodynamics. Food webs themselves are not as well known.

D. Demonstrate an understanding of the molecular basis of heredity.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous.
1. Compare DNA and RNA in terms of structure, nucleotides, and base pairs.	
2. Summarize the relationship among DNA, genes, and chromosomes.	
3. Explain how DNA functions as the code of life and the blueprint for proteins.	
4. Summarize the basic processes involved in protein synthesis (including transcription and translation).	
5. Summarize the characteristics of the phases of meiosis I and II.	
6. Predict inherited traits by using the principles of Mendelian genetics (including segregation, independent assortment, and dominance).	
7. Summarize the chromosome theory of inheritance and relate that theory to Gregor Mendel's principles of genetics.	

8. Compare the consequences of mutations in body cells with those in gametes.	
9. Exemplify ways that introduce new genetic characteristics into an organism or a population by applying the principles of modern genetics.	The new molecular biology methods are too numerous to expect any teacher to be up to date on them all.

E. Demonstrate an understanding of biological evolution and the diversity of life.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous.
1. Summarize the process of natural selection.	I think 1 and 4 are the same thing, or close enough that they should be combined.
2. Explain how genetic processes result in the continuity of life-forms over time.	I think 2 and 9 are the same thing, or close enough that they should be combined.
3. Explain how diversity within a species increases the chances of its survival.	I believe you mean to say genetic diversity. By just saying diversity, you could easily imply morphology (phenotype, not genotype).
4. Explain how genetic variability and environmental factors lead to biological evolution.	If you want to imply that evolution is a fact, then stick with this wording. Otherwise, change it to "... factors CAN lead to biological evolution."
5. Provide examples of scientific evidence in the fields of anatomy, embryology, biochemistry, and paleontology that underlie the theory of biological evolution.	Being able to provide examples straight out of high school is over the top knowledge. A student who scores a 5 on an AP Biology exam may not be able to give examples in all of those fields with clarity. I think 5 and 6 are the same thing, or close enough that they should be combined.
6. Summarize ways that scientists use data from a variety of sources to investigate and critically analyze aspects of evolutionary theory.	The phrase "critically analyze" is problematic. Suggest it be replaced by the word "test", so this it is clear that one approaches the study of evolution using testable hypotheses, not some other non-scientific methods.

7. Explain ways in which living things can be classified based on each organism's internal and external structure, their development, and relatedness of DNA sequence.	
8. Employ a phylogenetic tree to identify the evolutionary relationships among different groups of organisms.	I would insert "(similarities and differences)" after "evolutionary relationships".
9. Explain the theory of evolution (e.g., the Earth's present-day life forms evolved from earlier, distinctly different species).	This should be the Darwinian theory of evolution, not just the theory of evolution.

F. Demonstrate an understanding of the interrelationships among organisms and the biotic and abiotic components of their environments.	
1. Explain how the interrelationships among organisms (including predation, competition, parasitism, mutualism, and commensalism) generate stability within ecosystems.	It is not at all clear that ANY of these processes generates stability within any ecosystem. These are difficult concepts to test.
2. Explain how populations are affected by limiting factors (including density-dependent, density-independent, abiotic, and biotic factors).	
3. Illustrate the processes of succession in ecosystems.	I found this statement to be a little vague. What detail of illustration is it expected?
4. Exemplify the role of organisms in the geochemical cycles (including the cycles of carbon, nitrogen, and water).	I think 4, 5 and 6 are the same thing, or close enough that they should be combined.

5. Explain how ecosystems are maintained through naturally occurring processes (including maintaining the quality of the atmosphere, generating soils, controlling the hydrologic cycle, disposing of wastes, and recycling nutrients).	
6. Explain how human activities (including population growth, technology, and consumption of resources) impact the biosphere through changes in the physical, chemical, and biological cycles and processes.	

Chemistry Standards	Comments
A. Demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. These are concepts we struggle with at the university all of the time. The hope would be that if the students have been introduced to these items before, and properly, then our more rapid approach will not be so confusing and perhaps more confirming. I have doubts though as to whether the rote approach can overcome a lack of desire on the students part to do the best they can when faced with a challenge.
1. Employ appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.	

2. Experience the proper, hands-on use of some chemical equipment (e.g., pipet, buret, balance, spectrometer, gas chromatograph).	The use of a spectrometer and gas chromatograpy go beyond the preparation needed. Otherwise I strongly agree with the statement. I would remove the word some. The word allows for ambiguity. I would also remove gas chromatograph. The ability to use such an instrument is not a college readiness skill. Finally, change the word spectrometer to spectrophotometer. The correct use of standard glassware (beakers, graduated cylinders, burets) and their associated errors would be more valuable for a prepared student than just simply using a variety of lab equipment.
3. Record data and results from scientific measurements in a laboratory notebook properly, including the proper use of significant digits (both in recording a measurement and in calculating derived quantities) in appropriate metric units that reflect the precision and accuracy of each measurement.	
4. Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations.	I realize designing investigations is important - but in chemistry we rarely test hypotheses. This fits into the one-size fits all school of "the scientific method".
5. Organize and interpret the data from a controlled scientific investigation by using word processing, spreadsheets (including calculations, tables, and graphs), other technology, models, figures, and mathematics (including formulas, scientific notation, statistics, and dimensional analysis) to create a clear and concise scientific laboratory report.	I strongly agree with this statement EXCEPT the need for spreadsheets and the use of statistics.

6. Evaluate the results of a scientific investigation in terms of whether they verify or refute the hypothesis and what the possible sources of error are.	This is important for those students who are going to pursue a career in chemistry or a research career in the health field. I do not see it as important for an introductory course in chemistry. No investigation by itself can ""verify"" a hypothesis. It may support it or disprove it. Continuous failure to disprove it is as close to verification as you can get - ever!
7. Evaluate a technological design or product on the basis of designated criteria.	This statement is so broad that it is hard to know what is being stated or expected. Statement is vague and does not specifically address ultimate standard. This point should include more descriptive information as to the precise nature of its purpose. This is too vague to know what is expected. Delete it."
[Suggested additional standard]	I would add another statement. Students must be able to contrast the terms hypothesis, theory, and law. Most freshmen have no concept of what a scientific theory entails. K-12 educators seem to instill in students that a hypothesis becomes a theory, which becomes a law (which is impossible).

B. Demonstrate an understanding of atomic structure and nuclear processes.	Again, all of these concepts would provide a good background for a solid introduction to chemistry. I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. Most of this (nuclear) does not need to be "covered" in HS. There is already way too much material in these standards – and no way that students would come out of it with anything except a rote memorization of facts and algorithms. Much of what is here is simple regurgitation of facts.

	Some of these topics although covered in high school are re-taught at the college level in more depth. Was this section written by a nuclear chemist? This seems awfully over-weighted on material I think inappropriate at the HS level. Many of these topics are not taught in collegiate gen. hem. at the institutions I'm aware of. Understanding atomic structure is essential for an understanding of chemistry. Some understanding of nuclear processes is needed to become an informed citizen.
1. Illustrate electron configurations by using orbital notation for representative elements.	Electron configurations would be much better understood if the [core] valence notation were used. Stick with the big picture.
2. Summarize atomic properties (including electron configuration, ionization energy, electron affinity, atomic size, and ionic size).	They should know electron configurations but I don't expect them to know the other trends listed. I have no idea what (2) means.
3. Summarize the periodic table's property trends (including electron configuration, ionization energy, electron affinity, atomic size, ionic size, and reactivity).	Students should again be very familiar with electron configurations and able exposed to all the other subjects listed, but I don't expect them to already know all of those other areas.

4. Compare the nuclear reactions of fission and fusion to chemical reactions (including the parts of the atom involved and the relative amounts of energy released).	#4 - #9: Students need an exposure to all of these topics, but we teach all of this material. I students need to be strong in atomic structure, difference between fission and fusion, concept of half-life; I do not expect them to already know all of the information listed. The nuclear chemistry (4 through 9) isn't an essential entry skill and could be taught in college. Students should be aware of the parts of the atom. They are appropriate to teach in high school it just doesn't seem they are necessary as entry skills to college chemistry.
5. Compare alpha, beta, and gamma radiation in terms of mass, charge, penetrating power, and the release of these particles from the nucleus.	
6. Explain the concept of half-life, its use in determining the age of materials, and its significance to nuclear waste disposal.	
7. Apply the predictable rate of nuclear decay (half-life) to determine the age of materials.	
8. Analyze a decay series chart to determine the products of successive nuclear reactions and write nuclear equations for disintegration of specified nuclides.	Unnecessary for general knowledge of chemistry.
9. Employ the equation E = mc2 to determine the amount of energy released during nuclear reactions.	This is simple arithmetic, not chemistry. Delete it.
[Suggested additional standard]	We also employ calculations involving energy of a photon and the relationship between frequency and wavelength in the category of atomic structure. Bohr's model of the atom is also included.

C. Demonstrate an understanding of the structures and classifications of chemical compounds.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. The last ones are overkill for K-12
1. Predict the type of bonding (ionic or covalent) and the shape of simple compounds by using Lewis dot structures and oxidation numbers.	I strongly agree with this statement EXCEPT trying to tie it in with oxidation numbers. I have no idea what this means.
2. Interpret the names and formulas for ionic and covalent compounds.	
3. Explain how the types of intermolecular forces present in a compound affect the physical properties of compounds (including polarity and molecular shape).	Poorly worded - right now it appears to mean how IMFs affect shape - which is not what the authors intended (I hope).
4. Explain the unique bonding characteristics of carbon that have resulted in the formation of a large variety of organic structures.	Numbers 4, 5, 6, 7, 9, 10 are useful to know and will help students in the second semester of college chemistry but a case could be made that they are not needed for student success. If a student is well prepared for the first semester of college chemistry they should be able to make it through the second semester without having been exposed to this material in high school. That is not to say the information shouldn't be taught in high school I just don't think it is critical for success in college.
5. Illustrate the structural formulas and names of simple hydrocarbons (including alkanes and their isomers and benzene rings).	5-9 Organic chemistry as rote memorization again.

6. Identify the basic structure of common polymers (including proteins, nucleic acids, plastics, and starches).	6, 7, 9, and 10. For all of these statements they are too advanced, and no post-secondary instructor should expect incoming students to be acquainted with this terminology or these concepts in organic chemistry or biochemistry. For statement #6, identifying polymeric structures isn't expected prerequisite knowledge to be successful in a introductory college chemistry course. This topic would be taught in an introductory college chemistry course. My objection to Item #6 is the use of identify which usually implies memorizing structure. This, in my mind, reinforces an approach to chemistry that is not useful for the most part which is to try an remember everything. This leads to the notion that all is known and there is nothing left to determine or discover. The calls for classification may lead to this problem as well but at least the student would be required to make a decision when placing a structure into a class.
7. Classify organic compounds in terms of their functional group.	
8. Explain the effect of electronegativity and ionization energy on the type of bonding in a molecule.	The students need to get the basics of bonding in high school. They really need to understand why any type of bonding occurs in the first place, and then be able to predict if the bond is ionic or covalent. All of the topics listed above will be covered in the college class but many times the students have to learn all the basics along with the in-depth materials. Students can be much more successful is the basics have been mastered.
9. Classify polymerization reactions as addition or condensation.	What exactly do you mean by "Interpret the names and formulas for ionic and covalent compounds." Someone had a copy of Bloom's taxonomy. Sometimes those key words don't really capture what we actually do. Do you mean simply naming the compounds and deciding on the type of compound be the name or formula?

10. Classify organic reactions as addition, elimination, or condensation.	Knowledge of the types of chemical bonds, their properties, and shape is essential. As the introductory course is not a high-level organic chemistry course, knowledge of organic reaction classification is not essential. Can be a mere exercise in mechanism recognition and not an exercise in understanding the structures of organic molecules. Classifying organic reactions is too high of a level of expectation for high school students. This topic would be taught in freshman chemistry as well as organic chemistry.

D. Demonstrate an understanding of the types, the causes, and the effects of chemical reactions.	I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. Again, some of this isn't necessary at K-12 level. Students need to understand why reactions occur and what the different basic types of reactions are. A strong introduction to stoichiometry is also extremely important. As a non-chemist, these are all relevant to understanding how the world works.
1. Analyze and balance equations for simple synthesis, decomposition, single replacement, double replacement, and combustion reactions.	Labeling these reactions as such is a waste of time - it's school science. No one ever uses these terms except in general chemistry - we should not propagate them. Understanding the concept of the mole and its uses is essential in chemistry. Knowledge of reaction rate theory is not essential in an introductory course in chemistry.

2. Predict the products of acid-base neutralization and combustion reactions.	We also include predicting products of precipitation reactions, single replacement (given activity series) and a handful of decomposition and synthesis reactions.
3. Analyze the energy changes (endothermic or exothermic) associated with chemical reactions.	I don't know what this entails.
4. Apply the concept of moles to determine the number of particles of a substance in a chemical reaction, the percent composition of a representative compound, the mass proportions, and the mole-mass relationships.	
5. Predict the percent yield, the mass of excess, and the limiting reagent in chemical reactions.	Some of these items (5, 8) would be considered advanced for high school chemistry, perhaps more at the AP Chemistry level. An introduction to these ideas and concepts so that a conscientious student will have a good starting point in college chemistry is what I would consider as prepared.
6. Explain the role of activation energy and the effects of temperature, particle size, stirring, concentration, and catalysts in reaction rates.	6, 10 - how are these different? In real terms? 6, 8, 9, 10 aren't essential as entry skills to college chemistry. They could be taught in college. This level of understanding is more advanced than what should be expected. #6,7,8 are important but students can learn these in a college class if they have the fundamentals. They should be introduced to these subjects but the majority of the time should be on the others.
7. Summarize the oxidation and reduction processes (including oxidizing and reducing agents).	What are The oxidation and reduction processes?

8. Illustrate the uses of electrochemistry (including electrolytic cells, voltaic cells, and the production of metals from ore by electrolysis).	Electrochemistry is complex and difficult - I would wait. 8, 9, and 10. These statements are too advanced for what should be expected of incoming post-secondary students to know in order to be well prepared.
9. Summarize the concept of chemical equilibrium and Le Châtelier's principle.	
10. Explain the role of collision frequency, the energy of collisions, and the orientation of molecules in reaction rates.	

E. Demonstrate an understanding of the structure and behavior of the different phases of matter.	Not sure what value this brings to a HS student. These items seem to be appropriate as topics dealing with preparedness. They are worded so that an introduction is more the aim than facility, which some of the earlier items seemed to be doing. I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used.
1. Explain the effects of the intermolecular forces on the different phases of matter.	Poorly worded. All topics should be covered, but not with equal intensity. Should be emphasized.

2. Explain the behaviors of gas; the relationship among pressure, volume, and temperature; and the significance of the Kelvin (absolute temperature) scale, using the kinetic-molecular theory as a model.	Students need to be introduced to the properties of gases and learn to do the mathematics involved. All topics should be covered, but not with equal intensity. Those that I marked should be emphasized.
3. Apply the gas laws to problems concerning changes in pressure, volume, or temperature (including Charles's law, Boyle's law, and the combined gas law).	It is not necessary to separate out and memorize all the gas laws. All topics should be covered, but not with equal intensity. Those that I marked should be emphasized.
4. Illustrate and interpret heating and cooling curves (including how boiling and melting points can be identified and how boiling points vary with changes in pressure).	
5. Analyze the energy changes involved in calorimetry by using the law of conservation of energy as it applies to temperature, heat, and phase changes (including the use of the formulas $q = mc\Delta T$ [temperature change] and $q = mLv$ and $q = mLf$ [phase change] to solve calorimetry problems).	I have no idea what these equations q=mlv and q=Mlf are supposed to be. All topics should be covered, but not with equal intensity. Those that I marked should be emphasized.
6. Apply the ideal gas law ($pV = nRT$) to solve problems.	All topics should be covered, but not with equal intensity. Those that I marked should be emphasized.
7. Employ density to determine the mass, volume, or number of particles of a gas in a chemical reaction.	Why?

8. Analyze a product for purity by following the appropriate assay procedures.	Vague and doesn't necessarily fall under the above category of content. 8 and 9. This may be covered in well-structured secondary AP or Honors classes, but this is still more than should be expected from what students should know before entering post-secondary classes in chemistry. Don't know what this means.; Understanding the gas laws is essential in chemistry. Analyzing products is not essential in an introductory course in chemistry. Depends on how you define purity - ppt, ppm, ppb, ppt? Analytical instrumentation needs are too costly for this. Delete it.
9. Analyze a chemical process to account for the weight of all reagents and solvents by following the appropriate material balance procedures.	Why is this here in this section? All topics should be covered, but not with equal intensity. Those that I marked should be emphasized.

F. Demonstrate an understanding of the nature and properties of various types of chemical solutions.	Again, introducing these topics would certainly help ensure a prepared student but facility with these topics can take a long time even for the best students. I don't like the word choice "Demonstrate an understanding". How does one demonstrate their understanding? The term understanding is nebulous. A more appropriate, measurable term can be used. In general I find these standards very disappointing - they will only produce more of the same (i.e. a total lack of understanding of the basic principles of chemistry - structure and function. There is no attempt to relate the molecular level to the macroscopic level. These standards do not seem to take into account any of the research on teaching and learning in chemistry.

1. Summarize the process by which solutes dissolve in solvents, the dynamic equilibrium that occurs in saturated solutions, and the effects of varying pressure and temperature on solubility.	Too much in one statement here - are you talking about gases or solids? presumably both -but very different factors come into play.
2. Compare solubility of various substances in different solvents (including polar and nonpolar solvents and organic and inorganic substances).	
3. Illustrate the colligative properties of solutions (including freezing point depression and boiling point elevation and their practical uses).	Illustrate - what does that mean?
4. Carry out calculations to find the concentration of solutions in terms of molarity and percent weight (mass).	
5. Summarize the properties of salts, acids, and bases.	Summarize in what way? Salts have all kinds of properties.
6. Distinguish between strong and weak common acids and bases.	Understanding the properties of solutions is essential in chemistry. Understanding the details and calculations involved in colligative properties is not essential in an introductory course in chemistry.
7. Represent common acids and bases by their names and formulas.	
8. Employ the hydronium or hydroxide ion concentration to determine the pH and pOH of aqueous solutions.	8, 10, 13 aren't essential entry skills to college chemistry. Can be taught in college. Expectations too high. May be covered in an AP or Honors class, but not really necessary for students to be well prepared. pH and pOH calculation should await introduction in a post-secondary chemistry course. Why bring pOH in? We don't use it - why should HS students be taught it?

9. Explain how the use of a titration can determine the concentration of acid and base solutions	
10. Interpret solubility curves to determine saturation at different temperatures.	8, 10, 13 aren't essential entry skills to college chemistry. Can be taught in college. Not necessary at this stage in students' education.
11. Employ a variety of procedures for separating mixtures (including distillation, crystallization filtration, paper chromatography, and centrifuge).	Also, with item #11, chemical separation can be illustrated in a variety of ways but it seems the item just wants the students to use different procedures as though the idea was training. I don't see training specifically as part of college preparedness. Exposure or knowledge of most of these methods is not necessary to be well-prepared.
12. Employ solubility rules to write net ionic equations for precipitation reactions in aqueous solution.	
13. Employ the calculated molality of a solution to calculate the freezing point depression and the boiling point elevation of a solution.	8, 10, 13 aren't essential entry skills to college chemistry. Can be taught in college. For statement #13, it is sufficient to illustrate the colligative properties of solutions. Actual calculations and applications of colligative properties are taught in freshman chemistry. No colligative calculations
14. Represent neutralization reactions and reactions between common acids and metals by using chemical equations.	
[Suggested additional standard]	I notice there is absolutely no mention of molecular level diagrams or translating between symbolic, molecular and macroscopic phenomenon. - A grave omission.

Physics Standards	Comments
A. Demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.	These general topics for scientific inquiry as certainly appropriate for a prepared college student. Age appropriate.
1. Apply established rules for significant digits, both in reading scientific instruments and in calculating derived quantities from measurement.	
2. Employ appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.	
3. Employ scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.	
4. Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations.	
5. Organize and interpret the data from a controlled scientific investigation (including calculations in scientific notation, formulas, error and dimensional analysis) by using graphs, tables, models, diagrams, and/or technology.	
6. Evaluate the results of a controlled scientific investigation in terms of whether they refute or verify the hypothesis.	Verify is a bad word, as explained before

7. Evaluate conclusions based on qualitative and quantitative data (including the impact of parallax, instrument malfunction, or human error) on experimental results.	I don't agree with the idea of human error in a physical science experiment as an explanation for normal variation in outcome. A human error is a mistake that results in outlying data which is easily observed or conscientiously in a repeated experiment. Otherwise the normal experimental variation is indeterminant error for all sources including human. Indeterminant error may be a better choice of words.
8. Communicate and defend a scientific argument or conclusion.	
9. Apply appropriate safety procedures when conducting investigations.	

B. Demonstrate an understanding of the principles of force and motion and relationships between them.	Again these presentations would be an excellent way to set up high school students to do better in their early college science courses such as chemistry and biology. Being well versed in these topics would be expected of an AP Physics student since they might receive college credit.
1. Represent vector quantities (including displacement, velocity, acceleration, and force) and apply vector addition.	Are our HS students up to vector math? If done qualitatively, that would be another matter.
2. Apply formulas for velocity or speed and acceleration to one and two-dimensional problems including projectile motion.	
3. Interpret the velocity or speed and acceleration of one and two-dimensional motion on distance-time, velocity-time or speed-time, and acceleration-time graphs.	

4. Interpret the resulting motion of objects by applying Newton's three laws of motion: inertia; the relationship among net force, mass, and acceleration (using F = ma); and action and reaction forces.	
5. Employ a free-body diagram to determine the net force and component forces acting upon an object.	
6. Distinguish between static and kinetic friction and the factors that affect the motion of objects.	
7. Explain how torque is affected by the magnitude, direction, and point of application of force.	Omit direction. Most high school physics courses consider forces to be perpendicular. Therefore, direction is not a factor. This topic will be taught in an introductory physics course and is inappropriate for high school.
8. Explain the relationships among speed, velocity, acceleration, and force in rotational systems.	Explain the relationships among angular speed, angular velocity, angular acceleration, and torque in rotational systems.

C. Demonstrate an understanding of the concepts of mechanical energy and momentum, including conservation of mechanical energy and conservation of momentum.	Again, a good introductory presentation would be great for college preparedness.
1. Apply energy formulas to determine potential and kinetic energy and explain the transformation from one to the other.	
2. Apply the law of conservation of energy to the transfer of mechanical energy through work.	
3. Explain, both conceptually and quantitatively, how energy can transfer from one system to another (including work, power, and efficiency).	Explain, both conceptually and quantitatively, by using the concepts of work and power, how energy is transferred from one system to another.

4. Explain, both conceptually and quantitatively, the factors that influence periodic motion.	Explain, both conceptually and quantitatively, the factors that influence harmonic motion. Restrict the statement to periodic motion of a simple pendulum. The concept of periodic motion entails some mathematics that are too complicated for high school physics. Such topics would be discussed in college physics courses after students complete college-level calculus.
5. Explain the factors involved in producing a change in momentum (including impulse and the law of conservation of momentum in both linear and rotational systems).	Explain the factors involved in producing a change in momentum in a linear and angular momentum in a rotational system. Include conservation principles and impulse.
6. Compare elastic and inelastic collisions in terms of conservation laws.	Compare the usefulness of conservation of energy and conservation of momentum for elastic and inelastic collisions.

D. Demonstrate an understanding of the properties of electricity and magnetism and the relationships between them.	These are excellent topics again for the curious physics student to have introduced prior to college.
1. Explain the characteristics of static charge and how a static charge is generated.	
2. Employ diagrams to illustrate an electric field (including point charges and electric field lines).	Requires students to understand the concept of vector fields. This is an inappropriate expectation for high school students. Such concepts are covered in college-level courses.
3. Summarize current, potential difference, and resistance in terms of electrons.	

4. Compare how current, voltage, and resistance are measured in a series and in a parallel electric circuit and identify the appropriate units of measurement.	
5. Analyze the relationships among voltage, resistance, and current in a complex circuit by using Ohm's law to calculate voltage, resistance, and current at each resistor, any branch, and the overall circuit.	Statement #5 and #8 address integration of knowledge not required at the high school level. To be college ready, students need to understand basic principles of electric circuits. Applications and integration of electric circuit concepts occurs in college.
6. Differentiate between alternating current (AC) and direct current (DC) in electrical circuits.	
7. Carry out calculations for electric power and electric energy for circuits.	
8. Summarize the function of electrical safety components (including fuses, surge protectors, and breakers).	Covered under laboratory safety in the undergraduate instructional laboratories.
9. Explain the effects of magnetic forces on the production of electrical currents and on current carrying wires and moving charges.	For statements #9-11, the relationship between electricity and magnetism is not appropriate for high school physics. These are topics discussed in college physics courses. Students need only understand basic concepts of electricity and magnetism to be college ready.
10. Explain how magnetic fields can be produced by electrical currents or by permanent magnets.	
11. Distinguish between the function of motors and generators on the basis of the use of electricity and magnetism by each.	

E. Demonstrate an understanding of the properties and behaviors of mechanical and electromagnetic waves.	Students should know basic terminology to describe waves (mechanical and electromagnetic). Basic knowledge of terminology is appropriate for college readiness. Application of such concepts occurs at the college level.
1. Analyze the relationships among the properties of waves (including energy, frequency, amplitude, wavelength, period, phase, and speed).	
2. Compare the properties of electromagnetic and mechanical waves.	
3. Analyze wave behaviors (including reflection, refraction, diffraction, and constructive and destructive interference).	
4. Distinguish the different properties of waves across the range of the electromagnetic spectrum.	
5. Illustrate the interaction of light waves with optical lenses and mirrors by using Snell's law and ray diagrams.	Illustrate the use of ray diagrams (when the wave nature of light is not important) in the analysis of lenses and mirrors.
6. Summarize the operation of lasers and compare them to incandescent light.	Summarize the operation of an light emitting diode LED and a LASER and compare these sources to an incandescent light source.

F. Demonstrate an understanding of the properties and behaviors of sound.	Students should know basic terminology to describe sound. Basic knowledge of terminology is appropriate for college readiness. Application of such concepts occurs at the college level.
1. Summarize the production of sound and its speed and transmission through various media.	

2. Explain how frequency and intensity affect the parts of the sonic spectrum.	
3. Explain pitch, loudness, and tonal quality in terms of wave characteristics that determine what is heard.	
4. Compare intensity and loudness.	Intensity is the key metric for physicists.
5. Apply formulas to determine the relative intensity of sound.	
6. Apply formulas in order to solve for resonant wavelengths in problems involving open and closed tubes.	
7. Explain how musical instruments produce resonance and standing waves.	
8. Explain how the variables of length, width, tension, and density affect the resonant frequency, harmonics, and pitch of a vibrating string.	Length, tension, and linear mass density. What does the width of the string have to do with resonance?

G. Demonstrate an understanding of the properties and behaviors of light and optics.	Students need to know what light is and the particle and wave nature of light. Most of the above statements are outcomes of a 3rd semester physics course and are inappropriate for high school students. The statements [below] are not required for college readiness.
1. Explain the particulate nature of light as evidenced in the photoelectric effect.	
2. Apply the inverse square law to determine the change in intensity of light with distance.	
3. Illustrate the polarization of light.	

4. Summarize the operation of fiber optics in terms of total internal reflection.	Total internal reflection can be included in the discussion of prisms, and refraction at dielectric interfaces.
5. Summarize the production of continuous, emission, or absorption spectra.	Summarize the production of emission or absorption line spectra.
6. Illustrate the diffraction and interference of light.	
7. Identify the parts of the eye and explain their function in image formation.	

H. Demonstrate an understanding of nuclear physics and modern physics.	I would think this whole area would be best left for college physics. I believe that although this topic is an excellent one, our physics professors don't get to this until clear at the end of the second semester and so therefore is probably a topic that does not need to be part of college preparedness. Students need a basic understanding of the principles of nuclear physics and modern physics. However, they do not need to do higher level processing of this information to be college ready in physics.
1. Compare the strong and weak nuclear forces in terms of their roles in radioactivity.	If item 1 is meant for college preparation, separating it from the total spectrum of forces is confusing. Students learn about the forces in nature during the study of fundamental particles.
2. Predict the resulting isotope of a given alpha, beta, or gamma emission.	
3. Apply appropriate procedures to balance nuclear equations (including fusion, fission, alpha decay, beta decay, and electron capture).	

4. Interpret a representative nuclear decay series.	
5. Explain the relationship between mass and energy that is represented in the equation E = mc2 according to Einstein's special theory of relativity.	Again, this is just arithmetic, not physics.
6. Compare the value of time, length, and momentum in the reference frame of an object moving at relativistic velocity to those values measured in the reference frame of an observer by applying Einstein's special theory of relativity.	

I. Demonstrate an understanding of the principles of fluid mechanics.	Students need a basic understanding of the principles of fluid mechanics. However, they do not need to do higher level processing of this information to be college ready in physics.
1. Predict the behavior of fluids (including changing forces) in pneumatic and hydraulic systems.	
2. Explain the factors that affect buoyancy.	
3. Explain how the rate of flow of a fluid is affected by the size of the pipe, friction, and the viscosity of the fluid.	
4. Exemplify the relationship between velocity and pressure by using Bernoulli's principle.	

J. Demonstrate an understanding of the principles of thermodynamics.	Introduction of any of these topics to a curious physics student would certainly prepare them for college physics and chemistry courses.
1. Summarize the first and second laws of thermodynamics.	

2. Explain the relationship among internal energy, heat, and work.	
3. Explain thermal expansion in solids, liquids, and gases in terms of kinetic theory and the unique behavior of water.	
4. Differentiate heat and temperature in terms of molecular motion.	
5. Summarize the concepts involved in phase change.	
6. Apply the concepts of heat capacity, specific heat, and heat exchange to solve calorimetry problems.	

Physical Science	Comments
A. Physical Science: Scientific Inquiry - Demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.	
1. Generate hypotheses on the basis of credible, accurate, and relevant sources of scientific information.	
2. Employ appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.	
3. Employ scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.	

4. Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations.	
5. Organize and interpret the data from a controlled scientific investigation by using mathematics (including formulas and dimensional analysis), graphs, models, and/or technology.	
6. Evaluate the results of a controlled scientific investigation in terms of whether they refute or verify the hypothesis.	Verification is not possible
7. Evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).	7. and 8. These are unnecessary for adequate preparation for post-secondary education.
8. Compare the processes of scientific investigation and technological design.	Might also fit into any of the other science areas as well.
9. Apply appropriate safety procedures when conducting investigations.	

B. Chemistry: Structure and Properties of Matter - Demonstrate an understanding of the structure, bonding, and properties of atoms and molecules.	
1. Compare the subatomic particles (protons, neutrons, electrons) of an atom with regard to mass, location, and charge, and explain how these particles affect the properties of an atom (including identity, mass, volume, and reactivity), as well as employ the atomic number and mass number to calculate the number of subatomic particles for a given isotope of an element.	
2. Predict the charge that a representative element will acquire according to the arrangement of electrons in its outer energy level and explain that elements interact by transferring or sharing outermost electrons to form various kinds of bonds (ionic, covalent, metallic).	This is too hard - it's graduate student level thinking. Delete.
3. Compare fission and fusion and explain the consequences that the use of nuclear applications (including medical technologies, nuclear power plants, and nuclear weapons) can have.	

C. Chemistry: Structure and Properties of Matter - Demonstrate an understanding of various properties and classifications of matter including compounds, mixtures, and solutions.	
1. Explain the trends of the periodic table based on the elements' valence electrons and atomic numbers.	

2. Distinguish chemical properties of matter (including reactivity) from physical properties of matter (including boiling point, freezing/melting point, density [with density calculations], solubility, viscosity, and conductivity).	
3. Infer the practical applications of organic and inorganic substances on the basis of their chemical and physical properties.	
4. Illustrate the difference between a molecule and an atom.	
5. Classify matter as a pure substance (either an element or a compound) or as a mixture (either homogeneous or heterogeneous) on the basis of its structure and/or composition.	
6. Compare the properties of the four states of matter—solid, liquid, gas, and plasma—in terms of the arrangement and movement of particles and explain processes of phase change (in terms of temperature, heat transfer, and particle arrangement).	
7. Classify various solutions as acids or bases according to their physical properties, chemical properties (including neutralization and reaction with metals), generalized formulas, and pH (using pH meters, pH paper, and litmus paper).	
8. Explain the role of bonding in achieving chemical stability.	

D. Chemistry: Structure and Properties of Matter - Demonstrate an understanding of chemical reactions.	
1. Explain how the process of covalent bonding provides chemical stability through the sharing of electrons and classify compounds as crystalline or molecular based on whether their outer electrons are transferred or shared.	
2. Predict the ratio by which the representative elements combine to form binary ionic compounds, and represent that ratio in a chemical formula.	
3. Distinguish between chemical changes (including the formation of gas or reactivity with acids) and physical changes (including changes in size, shape, color, and/or phase).	
4. Summarize characteristics of balanced chemical equations (including conservation of mass and changes in energy in the form of heat—that is, exothermic or endothermic reactions).	
5. Summarize evidence (including the evolution of gas; the formation of a precipitate; and/or changes in temperature, color, and/or odor) that a chemical reaction has occurred.	
6. Apply a procedure to balance equations for a simple synthesis or decomposition reaction.	

7. Recognize simple chemical equations (including single replacement and double replacement) as being balanced or not balanced.	
8. Predict the amount of product or reactant from the other using the mole concept and balanced chemical equation.	

E. Physics: The Interactions of Matter and Energy - Demonstrate an understanding of the nature of forces and motion.	
1. Explain the relationship among distance, time, direction, and the velocity of an object.	
2. Apply the formula v = d/t to solve problems related to average speed or velocity.	
3. Explain how changes in velocity and time affect the acceleration of an object.	
4. Apply the formula a = (vf-vi)/t to determine the acceleration of an object.	
5. Explain how acceleration due to gravity affects the velocity of an object as it falls.	
6. Represent the linear motion of objects on distance-time graphs.	
7. Explain the motion of objects on the basis of Newton's three laws of motion: inertia; the relationship among force, mass, and acceleration; and action and reaction forces.	
8. Apply the formula F = ma to solve problems related to force.	

9. Explain the relationship between mass and weight by using the formula FW = mag.	
10. Explain how the gravitational force between two objects is affected by the mass of each object and the distance between them.	
11. Explain the theory of special relativity.	I'm not sure that a physical science student would be expected to explain the Special Theory of Relativity. Not required for college readiness. Delete - too few teachers can do this effectively.

F. Physics: The Interactions of Matter and Energy - Demonstrate an understanding of the nature, conservation, and transformation of energy.	Same general comment, I don't see the value at this level.
1. Explain how the law of conservation of energy applies to the transformation of various forms of energy (including mechanical energy, electrical energy, chemical energy, light energy, sound energy, and thermal energy).	
2. Explain the factors that determine potential and kinetic energy and the transformation of one to the other.	
3. Explain work in terms of the relationship among the force applied to an object, the displacement of the object, and the energy transferred to the object.	

4. Apply the formula W = Fd to solve problems related to work done on an object in motion.	
5. Explain how objects can acquire a static electric charge through friction, induction, and conduction, and explain that materials that contain equal amounts of positive and negative charges are electrically neutral, but that a very small excess or deficit of negative charges on a material produces noticeable electrical forces.	
6. Explain the relationships among voltage, resistance, and current in Ohm's law.	
7. Apply the formula V = IR to solve problems related to electric circuits.	
8. Represent an electric circuit by drawing a circuit diagram that includes the symbols for a resistor, switch, and voltage source.	
9. Compare the functioning of simple series and parallel electrical circuits.	
10. Compare alternating current (AC) and direct current (DC) in terms of the production of electricity and the direction of current flow.	
11. Explain the relationship of magnetism to the movement of electric charges in electromagnets, simple motors, and generators.	Requires students to explain relationships between magnetism and electricity. This is not required for college readiness. Delete - too few teachers can do this effectively.

G. Physics: The Interactions of Matter and Energy - Demonstrate an understanding of the nature and properties of mechanical and electromagnetic waves.	
1. Illustrate ways that the energy of waves is transferred by interaction with matter (including transverse and longitudinal/compressional waves).	Not required for college readiness.
2. Summarize characteristics of waves (including displacement, frequency, period, amplitude, wavelength, and velocity as well as the relationships among these characteristics).	
3. Summarize the characteristics of the electromagnetic spectrum (including range of wavelengths, frequency, energy, and propagation without a medium).	
4. Summarize reflection and interference of both sound and light waves and the refraction and diffraction of light waves.	

Earth Sciences	Comments
A. Demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.	
1. Apply established rules for significant digits, both in reading scientific instruments and in calculating derived quantities from measurement.	

2. Employ appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.	
3. Employ scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.	
4. Design a scientific investigation with appropriate methods of control to test a hypothesis (including independent and dependent variables), and evaluate the designs of sample investigations.	
5. Organize and interpret the data from a controlled scientific investigation by using mathematics (including calculations in scientific notation, formulas, and dimensional analysis), graphs, tables, models, diagrams, and/or technology.	
6. Evaluate the results of a controlled scientific investigation in terms of whether they refute or verify the hypothesis.	Verify is a bad, inappropriate word to use here

B. Demonstrate an ability to problem solve.	What does this have to do with earth science? This skill is needed in all disciplines, not exclusively earth science.
1. Apply various strategies to approach problem-solving situations and to revise solution processes.	
2. Explain the meaning of a mathematical expression (i.e., a statement using numbers and symbols to represent mathematical ideas and real world situations).	

C. Explain and apply concepts of probability and statistics.	What does this have to do with earth science? This skill is needed in all disciplines, not exclusively earth science.
1. Explain that predictions based on sample data are inferential.	

D. Explain and apply concepts of measurement.	
1. Explain how to make estimates and approximations and when to use those approaches to solve problems.	
2. Explain the differences between the metric and the traditional U.S. measurement system and perform simple conversions between the two.	
3. Explain the difference between accuracy and precision and explain how to use significant digits appropriately.	
4. Explain that investigations and public communication among scientists must meet certain criteria in order to result in new understanding and methods. For example: explain that arguments must be logical and demonstrate consistency between natural phenomena revealed by investigations, and explain that the historical body of scientific evidence, and the methods and procedures used to obtain evidence, must be clearly reported and reproducible to enhance opportunities for further investigation.	

5. Evaluate conclusions based on qualitative and quantitative data (including the impact of parallax, instrument malfunction, or human error) on experimental results.	
6. Communicate and defend a scientific argument or conclusion.	

E. Demonstrate an understanding of the structure and properties of the universe.	
1. Summarize the properties of the solar system that support the theory of its formation along with the planets.	
2. Identify properties and features of the Moon that make it unique among other moons in the solar system.	
3. Summarize the evidence that supports the big bang theory and the expansion of the universe (including the red shift of light from distant galaxies and the cosmic background radiation).	
4. Explain the formation of elements that results from nuclear fusion occurring within stars or supernova explosions.	
5. Classify stars by using the Hertzsprung-Russell diagram.	
6. Compare the information obtained through the use of x-ray, radio, and visual (reflecting and refracting) telescopes.	
7. Summarize the life cycles of stars.	
8. Explain how gravity and motion affect the formation and shapes of galaxies (including the Milky Way).	

F. Demonstrate an understanding of the internal and external dynamics of solid Earth.	
1. Summarize theories and evidence of the origin and formation of Earth's systems by using the concepts of gravitational force and heat production.	
2. Explain the differentiation of the structure of Earth's layers into a core, mantle, and crust based on the production of internal heat from the decay of isotopes and the role of gravitational energy.	
3. Summarize theory of plate tectonics (including the role of convection currents, the action at plate boundaries, and the scientific evidence for the theory).	
4. Explain how forces due to plate tectonics cause crustal changes as evidenced in earthquake activity, volcanic eruptions, and mountain building.	
5. Analyze surface features of Earth in order to identify geologic processes (including weathering, erosion, deposition, and glaciation) that are likely to have been responsible for their formation.	
6. Explain how the dynamic nature of the rock cycle accounts for the interrelationships among igneous, sedimentary, and metamorphic rocks.	
7. Classify minerals and rocks on the basis of their physical and chemical properties and the environment in which they were formed.	

8. Summarize the formation of ores and fossil fuels and the impact on the environment that the use of these fuels has had.	

G. Demonstrate an understanding of the dynamics of Earth's atmosphere.	
1. Summarize the thermal structures, the gaseous composition, and the location of the layers of Earth's atmosphere.	
2. Summarize the changes in Earth's atmosphere over geologic time (including the importance of photosynthesizing organisms to the atmosphere).	
3. Summarize the cause and effects of convection within Earth's atmosphere.	
4. Attribute global climate patterns to geographic influences (including latitude, topography, elevation, and proximity to water).	
5. Explain the relationship between the rotation of Earth and the pattern of wind belts.	
6. Explain that relationships exist among the earth (geology and soil science), the water (hydrology and oceanography), and the atmosphere (meteorology and atmospherics), and that the relationship is best exemplified by the water cycle.	
7. Summarize possible causes of and evidence for past and present global climate changes.	

8. Explain that the earth is a body in space whose environmental system (the atmosphere, lithosphere, cryosphere, hydrosphere, and biosphere) depends largely on the sun for light and heat and that the current environment (e.g., geography and climate) is subject to change.	
9. Explain environmental processes (e.g., the carbon and nitrogen cycles) and their role in processing matter crucial for sustaining life.	
10. Summarize the evidence for the likely impact of human activities on the atmosphere (including ozone holes, greenhouse gases, acid rain, and photochemical smog).	
11. Predict weather conditions and storms (including thunderstorms, hurricanes, and tornados) on the basis of the relationship among the movement of air masses, high and low pressure systems, and frontal boundaries.	

H. Demonstrate an understanding of Earth's freshwater and ocean systems.	The geophysical processes are more profitable for students since these are seen in physical science courses in college as well as astronomy.
1. Summarize the location, movement, and energy transfers involved in the movement of water on Earth's surface (including lakes, surface-water drainage basins [watersheds], freshwater wetlands, and groundwater zones).	

2. Illustrate the characteristics of the succession of river systems.	
3. Explain how karst topography develops as a result of groundwater processes.	
4. Compare the physical and chemical properties of seawater and freshwater.	
5. Explain the results of the interaction of the shore with waves and currents.	
6. Summarize the advantages and disadvantages of devices used to control and prevent coastal erosion and flooding.	
7. Explain the effects of the transfer of solar energy and geothermal energy on the oceans of Earth (including the circulation of ocean currents and chemosynthesis).	
8. Analyze environments to determine possible sources of water pollution (including industrial waste, agriculture, domestic waste, and transportation devices).	

I. Demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of its organisms.	
1. Summarize the conditions of Earth that enable the planet to support life.	
2. Summarize the divisions of the geologic time scale and illustrate the changes (in complexity and/or diversity) of organisms that have existed across these time units.	

3. Summarize how fossil evidence reflects the changes in environmental conditions on Earth over time.	
4. Match dating methods (including index fossils, ordering of rock layers, and radiometric dating) with the most appropriate application for estimating geologic time.	
5. Infer explanations concerning the age of the universe and the age of Earth on the basis of scientific evidence.	

Mathematics Standards

Thirty-four participants submitted reviews of the mathematics standards. Eighty-five standards are recommended for deletion based on receiving less than 80 percent agreement on inclusion (*indicated by gray highlighting*). Generally, comments for the Precalculus and Probability and Statistics sections indicate that the rigor is beyond the entry-level college expectation.

Table 4. Number of standards by science subject area

Subject Area	Delete	Total Standards
Algebra	19	52
Geometry	6	55
Precalculus	26	52
Probability and Statistics	34	45
Total Standards	**85**	**204**

Algebra Standards	Comments
ALGEBRA	In addition to looking at the coverage of knowledge and skills, it is important to address the level of difficulty for each learning outcome. This could be accomplished by providing one sample assessment item for each learning outcome. I have had students that placed into our developmental MAT 101 Beginning Algebra course that have told me that they took mathematics through Calculus in high school. So while this student was probably exposed to most of the Algebra and Precalculus content listed here, the student was not able to demonstrate a sufficient level of mastery to predict likely success at the college level without taking courses that review this knowledge and these skills. MAT 101 Beginning Algebra and MAT 102 Intermediate Algebra are sequential courses that we use to prepare students for MAT 110 College Algebra.

A. Demonstrate and apply the techniques of problem solving, reasoning, communication, connections, and representation.	Given a problem, students should use their problem solving skills, reasoning, and connections to develop an approach to the problem that they can communicate and represent in an appropriate manner. These are concepts that are taught in our MAT150 course which prepares the student for the MAT 101.
1. Employ mathematical terminology appropriately.	Vocabulary is very important and I emphasize verbal and written communication of mathematical concepts. However, I believe most high school students who can “get the answer” without being able to express how, are college ready.
2. Apply algebraic methods to solve problems external to mathematics.	I do feel that technology in the classroom is helpful for standards (2) and (3). Students need to realize that real world applications often don’t have integer solutions. Not necessary. Students need to know how to think about external problems mathematically, but not necessarily algebraically.
3. Judge the reasonableness of mathematical solutions.	
4. Demonstrate an understanding of algebraic relationships symbolically, graphically, verbally, and numerically.	
5. Represent algebraic relationships in concrete models, pictorial models, and diagrams.	It is ideal for students to be able to use models and diagrams to represent relationships, but I believe it is sufficient if students can use equations and inequalities to solve problems.

6. Represent algebraic relationships on handheld computing devices, in spreadsheets, and in computer algebra systems.	Again, it is ideal for students to be able to use computer software as well as calculators, but I believe all that is necessary is being able to use handheld devices. #7 – CAS calculators should not be allowed at this level. While the ability to represent algebraic relationships on handheld computing devices, in spreadsheets, and in computer algebra systems is nice, not all student at the secondary level in rural SC have this opportunity. If a student possesses a good manual foundation in algebra, they can learn these technology devices quickly on the college level. While I agree that students should be exposed to technology in the classroom, it should not be a major focus area in algebra. We expect students to perform simple calculations and algebraic work without the use of a calculator. Although we encourage the use of technology in the learning process for visualization and application problems, no calculators or computers are allowed on Calculus I for Science and Engineering exams. Currently taught in such a way to get in the way of real understanding. While technology may be necessary in some areas, algebra is not one of them. Use of technology is so varied and the manipulation skills are generally non-transferable between technologies so that most of these skills are retaught as necessary at each level.
7. Recognize the common mathematical meanings of equal signs, parentheses, superscripts, and subscripts.	

B. Demonstrate processes and understanding of functions, systems of equations, and systems of linear inequalities.	These are all included in the outcomes of our College Algebra courses. Students entering Calculus need to have all these skills. Most of the topics in this section are in the beginning college level course. Most of the topics in this section are in the beginning college level course.; There are no statements regarding systems of equations in this section. We teach these concepts in MAT102 which prepares the student for MAT 110. We teach this in MAT110.
1. Solve systems of linear inequalities algebraically.	Why is "solve systems of linear inequalities algebraically" listed but no mention is made of solving systems of linear EQUATIONS? Systems of linear equations are ubiquitous in the mathematical sciences. They appear much more often than systems of linear inequalities. If given the choice, I would want students to be able to solve linear equations before linear inequalities.
2. Solve systems of linear inequalities graphically.	
3. Model suitable problems by a system of linear inequalities.	There should be standards similar to (1), (2), and (3) for systems of equations. Competencies that are marked with a "disagree" are competencies currently taught in our Math 110-College Algebra course.
4. Carry out procedures to perform operations on polynomial functions (including f(x) + g(x), f(x) – g(x), f(x) • g(x), and f(x)/g(x)).	Functional notation needs to be mentioned here somewhere. It doesn't matter if a student can add two functions (f(x)+g(x)) if they don't truly understand f(x). Why just polynomial functions? All these operations apply to rational functions, exponential functions, logarithmic functions.

5. Determine an algebraic expression for a composition of given functions.	Competencies that are marked with a "disagree" are competencies currently taught in our Math 110-College Algebra course.
6. Graph translations of a given function.	I am assuming that for most cases, college ready in mathematics means calculus ready. At the two year level, the first credit bearing mathematics course is college algebra for most programs. A student would be ready for college algebra if they know 1 - 5 above. 6-8 would be necessary and helpful for entry into a calculus course. MTC covers items 6, 7 and 8 in MAT 110 College Algebra. Competencies that are marked with a "disagree" are competencies currently taught in our Math 110-College Algebra course. Why is this separate from #7? Particularly if #4 only covers polynomial functions?
7. Apply the basic transformations to the graph of a function.	Competencies that are marked with a "disagree" are competencies currently taught in our Math 110-College Algebra course.
8. Graph discontinuous step and piecewise-defined functions.	

C. Demonstrate an understanding of quadratic equations and the complex number system.	These are all included in the outcomes of our College Algebra courses. Students entering Calculus need to have all these skills. These topics are covered in Mat 102, which is a credit bearing mathematics option for most health programs at the two year college level. Covered in MAT110. We teach this in MAT 102 and MAT 110.
1. Perform operations with complex numbers.	Students will not understand the importance of any of these when they can solve problems with a calculator.

2. Solve quadratic equations algebraically (including by factoring, completing the square, and applying the quadratic formula).	I think it's enough to be able to solve quadratic equations by factoring and by either the quadratic formula or completing the square.
3. Apply the discriminant to determine the number and type of solutions of a quadratic equation.	MTC covers item 3 above in MAT 110 College Algebra.
4. Solve word problems involving quadratic models.	
5. Recognize the basic shape of a graph of a quadratic function and the relationships between the graph and its roots.	
[Suggested additional standard]	In particular, I like the mention of recognizing the graph of a quadratic function, but there should be a standard about producing the graph of a quadratic function whose equation is in standard form, either here or in the conic sections component.; What about graphing quadratic functions? Finding max/min values?; Although (5) says "recognize the basic shape of a graph of a quadratic function and the relationships between the graph and its roots," it DOES NOT say "graph a quadratic function." I believe students should be able to do that too.

D. Demonstrate an understanding of non-linear functions and algebraic expressions.	These are all included in the outcomes of our College Algebra courses. Students entering Calculus need to have all these skills. Again, these topics are covered in Intermediate and College algebra at the two-year college level. Both courses are credit bearing at this level. Topics 1-10 would be necessary for entry into calculus. Covered in MAT110. These are concepts in MAT 110.

1. Perform operations (including multiplication, exponentiation, and division) with polynomial expressions.	What about graphing polynomial/rational functions?
2. Determine specified points (including zeros, maximums, and minimums) of polynomial functions.	Items listed as "disagree" are those competencies currently taught in our Math 110-College Algebra. MTC covers items 2, 5, 9, 11 and 12 in MAT 110 College Algebra.
3. Factor polynomial expressions (including factoring by grouping, factoring the difference between two squares, factoring the sum of two cubes, and factoring the difference between two cubes).	Students should be able to determine zeroes, maxima, and minima for quadratics but not necessarily all polynomials. Exponential and logarithmic functions and equations are covered in our first college course.
4. Simplify algebraic expressions involving rational exponents.	
5. Simplify algebraic expressions involving logarithms.	Items listed as "disagree" are those competencies currently taught in our Math 110-College Algebra.
6. Perform operations with expressions involving rational exponents (including addition, subtraction, multiplication, division, and exponentiation).	Regarding 6: What sort of simplification involving addition and subtraction of rational powers is expected? Of course there are well known rules for multiplication, division and exponentiation of rational powers. But what is expected for e.g.: x^(1/2) + x^(1/3)?
7. Perform operations with rational expressions (including addition, subtraction, multiplication, and division).	I believe students should be able to graph rational functions and simple functions involving rational exponents (i.e. the square root function, the cubed root function, etc)?
8. Solve radical equations algebraically.	Again, these topics are covered in Intermediate and College algebra at the two-year college level. Both courses are credit bearing at this level. Topics 1-10 would be necessary for entry into calculus.
9. Solve logarithmic equations algebraically.	Why doesn't 9 include exponential equations as well? Items listed as "disagree" are those competencies currently taught in our Math 110-College Algebra.

10. Solve equations involving rational expressions.	
11. Graph logarithmic functions.	I think it's more important to recognize the graph's shape and to be able to graph it with technology. Items listed as "disagree" are those competencies currently taught in our Math 110-College Algebra. Students should be able to determine zeroes, maxima, and minima for quadratics but not necessarily all polynomials. Exponential and logarithmic functions and equations are covered in our first college course. I can't disagree with graphing logarithmic and exponential functions, but I think that solving logarithmic and exponential equations is more important.
12. Graph exponential functions.	Items listed as "disagree" are those competencies currently taught in our Math 110-College Algebra.
[Suggested additional standard]	Add: Addition and subtraction of polynomials. Factoring of trinomials. Expand logarithimic expressions. Solve equations involving rational exponents algebraically. Solve exponential functions algebraically. Solve all of the above graphically. Graph rational expressions, including finding asymptotes and intercepts algebraically.

E. Demonstrate an understanding of conic sections.	These are all included in the outcomes of our College Trigonometry course. Students entering Calculus need to have all these skills. Students should have an introductory knowledge of circles and a glance at the other conic sections. All are college algebra topics. Even for calculus, if one emphasizes the use of technology, the manual skill is not necessary. What is necessary is a general understanding of the conics general characteristics and their graphs, i.e., so that when a student sees a graph they recognize the existence of an asymptote or that the graphs are continuous, even though a gap appears when using some technologies. Conic sections are not a “mainstream” topic and they tend to be covered at a number of different levels within the college curriculum. Covered in MAT 110. These are taught in MAT 110 and MAT 111.
1. Graph the circle whose equation is given in standard form.	MTC covers items 1 and 2 in MAT 110 College Algebra. Why does the circle have to be written in standard form? Students should be able to write the standard form given the general form. Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.

2. Write an equation of a circle centered at the origin given its radius.	I also believe students should know how to graph conic sections that are not centered at the origin. #2 and #6 Centered at the origin? This shows absolutely no understanding. The center should be anywhere in the plane. Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course. Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.
3. Graph the ellipse whose equation is given in standard form.	MTC covers items 3, 4, 5, 6 and 7 in MAT 111 College Trigonometry. #3 and #5 Again, why can’t the student find the standard form? Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.
4. Write the equation of an ellipse given information about its major axis, minor axis, or vertices.	I don’t think graphing ellipses and conic sections are necessary to be college-ready. Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.
5. Graph the hyperbola whose equation is given in standard form.	As mentioned above, I think that graphing a parabola whose equation is in standard form could be added here. Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.“”

6. Write an equation of a hyperbola centered at the origin with specified vertices.	Again 6: Suppose a hyperbola centered at the origin has vertices (-a,0) and (a,0). How does this determine its equation? Of course, it doesn't! Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.
7. Match the equation of a conic section with its graph.	Items listed as “disagree” are competencies currently taught in our Math 110-College Algebra course.

F. Demonstrate an understanding of sequences and series.	This should be in a first year college course. This knowledge is not necessary before taking college math courses. It is covered in depth in some college courses and can be learned then. I don't think this information is necessary to be college-ready. I do not think that an understanding of sequences and series is necessary for college readiness. Covered in MAT 111. This is taught in MAT 111.
1. Categorize a sequence as arithmetic, geometric, or neither.	These skills will aid one's understanding of some aspects of probability and statistics but can be learned and are not essential for college success. MTC covers sequences and series in MAT 111 College Trigonometry. Items selected as "disagree" are competencies currently taught in our Math 110-College Algebra course.
2. Write a specified term of an arithmetic or geometric sequence when given the nth term of the sequence.	Items selected as "disagree" are competencies currently taught in our Math 110-College Algebra course.

3. Write a formula for the nth term of an arithmetic or geometric sequence when given at least four terms of the sequence.	Items selected as "disagree" are competencies currently taught in our Math 110-College Algebra course.
4. Represent an arithmetic or geometric series using sigma notation.	Items selected as "disagree" are competencies currently taught in our Math 110-College Algebra course.
5. Calculate the sum of an arithmetic or geometric series written in sigma notation.	Do you mean when the student is given the formula, or should they know the formula?
6. Write the first terms of a sequence that is defined recursively.	Items selected as "disagree" are competencies currently taught in our Math 110-College Algebra course.
7. Define a sequence recursively when given four or more consecutive terms of the sequence.	Of course four, or any finitely many consecutive terms, of a sequence is not sufficient to uniquely define the sequence! I presume you mean ARITHMETIC or GEOMETRIC sequence.

Geometry Standards	Comments
GEOMETRY	I'm not sure that geometry is necessary for success in college, but the processes learned in geometry are beneficial to developing the logic required to succeed in most any college-level mathematics course. Geometry must to taught well in high school since there is no college geometry offering in our two year college system. These topics are taught on a variety of levels. Some are not taught in any of the courses that we teach at YTC. We teach all of these concepts in MAT 150. However, some we cover as review. These were marked as Agree.

A. Demonstrate and apply the mathematical processes of problem solving, reasoning and proof, communication, connections, and representation.	These skills have more importance to particular majors and to the SAT rather than to college readiness at the two-year level. The ability to perform these skills does indicate that a student can think abstractly, a skill that is necessary. I believe that the[se] geometry standards are only necessary if the student is majoring in math.
1. Demonstrate an understanding of the axiomatic structure of geometry by using undefined terms, definitions, postulates, theorems, and corollaries.	Although I believe that developing a geometry from axioms is beneficial for students' logic and abstract thinking, sadly, for the courses that satisfy general education requirements at Clemson University, a thorough background in geometry is not necessary.
2. Communicate knowledge of geometric relationships by using mathematical terminology appropriately.	
3. Apply basic rules of logic to determine the validity of the converse, inverse, and contrapositive of a conditional statement.	A student could be college ready and still need review of contrapositive. Maybe #3 and #4 would be OK if high schools have the equipment.
4. Formulate and test conjectures by using a variety of tools such as drawing, written or concrete models, graphing calculators, spreadsheets, and dynamic geometry software.	
5. Apply inductive reasoning to formulate conjectures.	
6. Apply deductive reasoning to validate conjectures with formal and informal proofs, and give counterexamples to disprove a statement.	Needs to be emphasized. Students need to understand the idea of formal proof.

7. Explain the historical development of geometry.	Understanding the history of geometry is impressive but not necessary for being successful in college mathematics. “Explaining the historical development of geometry,” though interesting, is not necessary to be successful in university mathematics. There is no need for historical perspective for college readiness. Geometry must be taught well in high school since there is no college geometry offering in our two year college system. I disagree with (7) because the history of geometry may be interesting and provide some motivation for the problems, but I don’t think it’s necessary.
8. Connect geometry with other branches of mathematics.	8,9,10. Very useful, not necessary.
9. Demonstrate an understanding of how geometry applies to in real-world contexts (including architecture, construction, farming, and astronomy).	
10. Demonstrate an understanding of geometric relationships (including constructions through investigations by using a variety of tools such as straightedge, compass, Patty Paper, dynamic geometry software, and handheld computing devices).	

B. Demonstrate an understanding of the properties of basic geometric figures and the relationships between and among them.	We teach these concepts in MAT150.
1. Apply properties of parallel lines, intersecting lines, and parallel lines cut by a transversal to solve problems.	These geometry skills are of importance to a two-year curriculum.
2. Employ the congruence of figures to solve problems.	
3. Employ direct measurement to determine the length of a segment, degree of an angle, and distance from a point to a line.	Direct measurement is not really a geometric process.
4. Carry out a procedure to create geometric constructions (including the midpoint of a line segment, the angle bisector, the perpendicular bisector of a line segment, the line through a given point that is parallel to a given line, and the line through a given point that is perpendicular to a given line).	I know I keep making the same comment, but . . . this seems non-ESSENTIAL, though valuable. This should be done using straight edge and compass methods. Computer programs simplify these methods so that students are not gaining an understanding of the process.
5. Apply scale factors to solve problems involving scaled drawings and models.	

C. Demonstrate an understanding of the properties of triangles and of relationships between and among triangles.	Very applicable to a two year curriculum of study. These standards are good preparation for trigonometry, which is essential for success in Calculus for Science and Engineering.
1. Compute the perimeter of a triangle.	
2. Compute the area of a triangle.	
3. Analyze how changes in dimensions affect the perimeter or area of triangles.	
4. Apply properties of isosceles and equilateral triangles to solve problems.	

5. Employ interior angles, exterior angles, medians, angle bisectors, altitudes, and perpendicular bisectors to solve problems.	
6. Apply the sum of angles of a triangle to solve problems.	
7. Apply the triangle inequality to solve problems.	
8. Apply congruence and similarity relationships among triangles to solve problems.	
9. Apply theorems to prove that triangles are either similar or congruent or neither.	
10. Apply the Pythagorean theorem and its converse to solve problems.	Should include the Law of Cosines and Law of Sines.
11. Employ the properties of 45-45-90 and 30-60-90 triangles to solve problems.	

D. Demonstrate an understanding of the properties of quadrilaterals and other polygons and the relationships between and among them.	
1. Demonstrate how to find the area and perimeter of basic figures.	
2. Compute measures of interior and exterior angles of polygons.	
3. Analyze how changes in dimensions affect the perimeter or area of quadrilaterals and regular polygons.	
4. Apply properties and attributes of quadrilaterals and regular polygons and their component parts to solve problems.	

5. Apply congruence and similarity relationships among shapes (including quadrilaterals and polygons) to solve problems.	

E. Demonstrate an understanding of the properties of circles, the lines that intersect them, and the use of their special segments.	Important but less so than the previous two sections to a two year curriculum.
1. State the formulae for the area and the circumference of a circle and how to use them.	MTC covers the length of an arc in MAT 111 College Trigonometry.
2. Analyze how a change in the radius affects the circumference or area of a circle.	
3. Compute the length of an arc or the area of a sector of a circle.	A very basic look at some of the concepts of #3 through #6 could be taught in high school with success, but many are taught in college; and I am beginning to wonder about the available time in both places.
4. Apply properties of the component parts of a circle (including radii, diameters, chords, sectors, arcs, and segments) to solve problems.	
5. Apply properties of lines that intersect circles (including two secants, two tangents, and a secant and a tangent) to solve problems.	
6. Apply properties of central angles, inscribed angles, and arcs of circles to solve problems.	

F. Demonstrate an understanding of transformations in coordinate geometry, and vector.	Taught in college algebra or physics at the two year level. Nice to know but not a requirement. These skills could be learned at the two year level. Most of these are included in the outcomes of our College Trigonometry course. Students entering Calculus need to have all these skills. I don't think this is necessary to be college-ready.; "..., and vector." What does this mean? What about vectors?; Covered in Mat111.
1. Employ the distance formula to solve problems.	I believe these concepts are taught in college.
2. Employ the midpoint formula to solve problems.	MTC covers items 1 and 2 in MAT 110 College Algebra.
3. Apply transformations—translation, reflection, rotation, and dilation—to figures in the coordinate plane by using sketches, coordinates, and algebraic expressions.	If we require students to know this information, I would also require that they generalize these concepts to three dimensions. That is, "Apply matrix transformations to vectors in space." That way, students could also see perpendicularity in terms of a vector and a plane.
4. Apply transformations (including translation and dilation) to figures in the coordinate plane using matrices.	Items listed as "disagree" are currently taught in Math 111-College Trigonometry.
5. Represent the sum of two vectors geometrically using a parallelogram.	Items listed as "disagree" are currently taught in Math 111-College Trigonometry.
6. Determine the magnitude and direction of the sum of two vectors by using a scale drawing and direct measurement.	Items listed as "disagree" are currently taught in Math 111-College Trigonometry. What are students supposed to learn from #6 and #8? Using the Law of Sines and Law of Cosines, students can solve these problems exactly.
7. Compute the magnitude of the sum of two perpendicular vectors by using the Pythagorean theorem.	Items listed as "disagree" are currently taught in Math 111-College Trigonometry.

8. Determine the direction of the sum of two perpendicular vectors by using a scale drawing and direct measurement.	Items listed as "disagree" are currently taught in Math 111-College Trigonometry.

G. Compute the surface area and volume of three-dimensional objects.	I believe that the[se] geometry standards are only necessary if the student is majoring in math. Geometry is an important class but some students would do fine in college without it. These comments apply to the 3 previous components as well as this one. I think the computation of area, perimeter, surface area, and volume of various objects is good preparation for the application problems in calculus. Not necessary knowledge to be college-ready. Are students memorizing formulas? Are they expected just to apply formulas they are given? This section is unclear and most likely doesn't include anything that a student will carry away.
1. Compute the surface area of cones, cylinders, pyramids, prisms, spheres, and hemispheres.	They need to reason the formula and be able to use it. They don't necessarily need to have it memorized.
2. Compute the volume of cones, cylinders, pyramids, prisms, spheres, hemispheres, and composite objects.	
3. Apply congruence and similarity relationships among geometric objects to solve problems.	

Precalculus Standards	Comments
A. Understand and utilize the mathematical processes of problem solving, reasoning and proof, communication, connections, and representation.	MTC covers the items [below] in MAT 110 College Algebra and MAT 111 College Trigonometry. These are all included in the outcomes of our Precalculus course. Students entering Calculus need to have all these skills. Taught in Alg. and Trig here.
1. Distinguish between and among expressions, equations, relations and functions.	Not necessary to be college-ready.
2. Connect algebra and trigonometry with other branches of mathematics.	Items listed as "disagree" are currently taught in our Math 111-College Trig class.
3. Apply algebraic methods to solve problems in applied contexts.	
4. Judge the reasonableness of mathematical solutions.	
5. Demonstrate an understanding of algebraic and trigonometric relationships by using a variety of representations (including verbal, graphic, numerical, and symbolic).	Items listed as "disagree" are currently taught in our Math 111-College Trig class.

6. Understand how to represent algebraic and trigonometric relationships by using tools such as handheld computing devices, spreadsheets, and computer algebra systems (CASs).	CAS calculators should not be allowed at this level. Is not necessary and will distract from deeper understanding in most cases. There exists too many varied technologies with non-transferable skill sets. As I stated before, technology in the classroom can be very helpful for students who are visual learners and is good for solving more complicated application problems, but I wouldn't like to see this as a major focus of precalculus. I don't want my students to know how to use a calculator. I want them to know precalculus. Items listed as "disagree" are currently taught in our Math 111-College Trig class.

B. Demonstrate an understanding of the characteristics and behaviors of functions and the effect of operations on functions.	[All of these items] are currently taught in our Math 110-College Algebra or Math 111-College Trigonometry. These are all included in the outcomes of our Precalculus course. Students entering Calculus need to have all these skills. I am not sure that any of the above are "necessary" indicators for college readiness for students intending to pursue non mathematics, computer science, or science (biology, chemistry,...) majors. All of this is taught in college algebra. It is not necessary to be taught in high school Taught in Algebra Mat 110 here.

1. Carry out a procedure to graph parent functions of the following functions: y = xn, y = loga x, y = ln x, y = 1/x, y = ex, y = ax, y = sin x, y = cos x, y = tan x, y = csc x, y = sec x, and y = cot x.	Could be restated as, "Carry out a procedure to graph parent functions: y = x^n, etc." The phrase "of the following functions" doesn't seem to fit here. At first, I thought it meant transformations of the following parent functions, but transformations are in standard (2). I assume that "Carry out ..." the "n" in "x^n" is a positive integer. Again, I would like my students to be able to graph functions where n is rational, i.e. the square root function. I am not sure what is meant by procedure here, these are all functions for which students should know the graph. Also, to reinforce that these are functions, they should be written with parenthesis around the input, i.e., y=ln(x).
2. Graph transformations (including –f(x), a • f(x), f(x) + d, f(x - c), f(-x), f(b • x), |f(x)|, and f(|x|)) of a given function f.	
3. Analyze a graph to describe the transformation (including –f(x), a • f(x), f(x) + d, f(x - c), f(-x), f(b • x), |f(x)|, and f(|x|)) of parent functions.	
4. Analyze a function or the symmetry of its graph to determine whether the function is even, odd, or neither.	
5. Recognize and use connections among significant points of a function (including roots, maximum points, and minimum points), the graph of a function, and the algebraic representation of a function.	
6. Determine an algebraic expression for the composition of two given functions.	
7. Decompose a given function as the composition of two, usually simpler, functions.	

8. Know how to determine if a function has an inverse.	This requires an understanding of the domain of a function which has not appeared anywhere here. Also, if domain is included, then students should be able to determine if a function has an inverse both algebraically and geometrically.
9. Formulate the inverse of a function, if it exists.	

C. Demonstrate an understanding of the behaviors of polynomial and rational functions.	[All of these items] are currently taught in our Math 110-College Algebra or Math 111-College Trigonometry.
1. Graph quadratic and higher-order polynomial functions by analyzing intercepts and end behavior.	
2. Carry out a procedure to calculate the zeros of polynomial functions when given a set of possible zeros.	MTC covers the items above in MAT 110 College Algebra.
3. Determine characteristics of rational functions (including domain, range, intercepts, asymptotes, and discontinuities).	I believe (3) should also be under "Algebra."
4. Formulate a polynomial function that models a given problem.	
5. Solve polynomial equations algebraically.	
6. Find the roots of a rational equation.	
7. Carry out a procedure to solve polynomial inequalities algebraically.	
[Suggested additional standard]	Add: Solve polynomial equations and inequalities graphically.

D. Demonstrate through the mathematical processes an understanding of the behaviors of exponential and logarithmic functions.	[All of these items] are currently taught in our Math 110-College Algebra or Math 111-College Trigonometry. Taught here in Mat 110 (college algebra).
1. Determine characteristics of an exponential function (including domain, range, intercepts, extrema, and asymptotes) and sketch its graph.	
2. Determine characteristics of a logarithmic function (including domain, range, intercepts, and asymptotes) and sketch its graph.	
3. Apply the laws of exponents to solve equations involving rational exponents.	
4. Formulate exponential models for growth or decay.	
5. Apply the laws of logarithms to solve equations algebraically.	
6. Solve exponential equations algebraically.	
[Suggested additional standard]	Add: Solve logarithmec and exponential equations and inequalities graphically.

E. Demonstrate an understanding of trigonometric functions.	[All of these items] are currently taught in our Math 111-College Trigonometry. MTC covers the items above in MAT 111 College Trigonometry. Covered in trig.
1. Understand how angles are measured in either degrees or radians and how to convert between the two.	This should be taught in college, not high school I am not sure that the above items marked disagree are "necessary" indicators for college readiness for students intending to pursue non mathematics, computer science, or science (biology, chemistry,...) majors.
2. Plot points in a polar coordinate system.	Students don't use polar coordinates until Calculus II, but the introduction in precalc should be thorough enough for students to recognize the representation when they see it again. I am not sure that the above items marked disagree are "necessary" indicators for college readiness for students intending to pursue non mathematics, computer science, or science (biology, chemistry,...) majors.
3. Know both the right triangle and unit circle definitions of the sine, cosine, and tangent functions.	
4. Understand periodicity and recognize graphs of periodic functions, especially the trigonometric functions.	
5. Simplify and evaluate trigonometric expressions.	I am not sure that the above items marked disagree are "necessary" indicators for college readiness for students intending to pusue non mathematics, computer science, or science (biology, chemistry,...) majors.

6. Write a trigonometric function that models a given periodic phenomenon.	I am not sure that the above items marked disagree are "necessary" indicators for college readiness for students intending to pursue non mathematics, computer science, or science (biology, chemistry,...) majors.
7. Solve a triangle given the lengths of two sides and one angle.	
8. Solve trigonometric equations algebraically.	I am not sure that the above items marked disagree are "necessary" indicators for college readiness for students intending to pursue non mathematics, computer science, or science (biology, chemistry,...) majors.
9. Apply the laws of sines and cosines to solve problems.	
10. Graph the inverse functions of sine, cosine, and tangent.	I am not sure that the above items marked disagree are "necessary" indicators for college readiness for students intending to pursue non mathematics, computer science, or science (biology, chemistry,...) majors.
11. Apply trigonometric relationships to prove trigonometric identities.	
12. Compute the slope of a line, given the angle of inclination of the line.	
[Suggested additional standard]	Add: Solve trig equations graphically.

F. Demonstrate an understanding of the conic sections both geometrically and algebraically.	[All of these items] are currently taught in our Math 110-College Algebra or Math 111-College Trigonometry. Conic sections should not need to be given in standard form for students to graph them. They should be able to find the standard form. Again, this topic is covered at so many levels I would not consider it essential preparation. Covered in Mat 110 Algebra.
1. Graph a circle given in standard algebraic form.	
2. Write the equation of a circle given its radius and center.	
3. Calculate the coordinates of point(s) where a line intersects a circle.	
4. Graph an ellipse given in standard algebraic form.	
5. Graph an hyperbola given in standard algebraic form.	
6. Graph a parabola given in standard algebraic form.	

Probability and Statistics	Comments
PROBABILITY AND STATISTICS	I believe that of all the mathematical sciences, probability and statistics are two of the most practical. Therefore, I believe that these two subjects are absolutely necessary for ALL students to know. However, at Clemson University, a basic probability and statistics course is listed as one of our general education requirements. The other general education courses do not require students to know probability and statistics. Therefore, it is not necessary for incoming students to know much about probability and statistics.

A. Demonstrate and apply the mathematical processes of problem solving, reasoning and proof, communication, connections, and representation.	This section is too broad and not specific enough. While I would like for my students to have these skills when they enter college, they can take statistics in college and they can do well in a precalculus-calculus track without them. MTC covers [these items] in MAT 120 Probability and Statistics. This is taught in college probability and statistics, not high school.
1. Conduct simple probability experiments and collect data using spinners, dice, cards, and coins.	
2. Find measures of probability and statistics using tools such as computing devices, spreadsheets, and statistical software.	
3. Conduct simulations using random number tables and/or technology.	Items listed as "disagree" are competencies currently taught in our Math 120-Probability and Statistics course.

4. Design and conduct a statistical research project and produce a report that summarizes the findings.	I think a research project is a great idea. The collection, analysis, and interpretation of data is essential in most disciplines. However, I'm not sure that probability and statistics is necessary for college readiness. We have many students who come here with no experience in this subject who excel in their mathematics courses including any required probability and statistics. Items listed as "disagree" are competencies currently taught in our Math 120-Probability and Statistics course.
5. Apply the principles of probability and statistics to solve applied problems.	Items listed as "disagree" are competencies currently taught in our Math 120-Probability and Statistics course.
6. Judge the reasonableness of conclusions based on the sources of data, the design of the study, and the way the data are displayed and analyzed.	Items listed as "disagree" are competencies currently taught in our Math 120-Probability and Statistics course.
7. Compare data sets using graphs and numerical statistics.	Items listed as "disagree" are competencies currently taught in our Math 120-Probability and Statistics course.

B. Demonstrate an understanding of the design of a statistical study.	
1. Classify a data-collection procedure as a survey, an observational study, or a controlled experiment.	
2. Compare various random sampling techniques (including simple, stratified, cluster, and systematic).	
3. Critique data-collection methods and describe how bias can be controlled.	
4. Judge which experimental design will best answer a given question.	

C. Demonstrate an understanding of methodology for collecting, organizing, displaying, and interpreting data.	Covered in our Statistics course Mat 120.
1. Organize and interpret data by using pictographs, bar graphs, pie charts, dot plots, histograms, time-series plots, stem-and-leaf plots, box-and-whiskers plots, and scatterplots.	
2. Represent frequency distributions by using meaningful displays.	
3. Classify a scatterplot by shape (including linear, quadratic, and exponential).	
4. Classify graphically and analytically the correlation between two variables as either positive, negative, or zero.	
5. Determine a trend-line equation for a linear-pattern scatterplot using visual approximation.	
6. Determine a line of best fit for a scatterplot exhibiting a linear pattern.	
7. Explain the meaning of the correlation coefficient r.	
8. Employ interpolation or extrapolation to predict values based on the relationship between two variables.	DO NOT use statistical models for extrapolation!!! And explain to students why this is NOT appropriate.
[Suggested additional standard]	Add: Find and interpret R^2. Understand the distinction between correlation and causation.

D. Demonstrate an understanding of basic statistical methods for analyzing data.	
1. Classify a variable as either a statistic or a parameter.	
2. Compare descriptive and inferential statistics.	
3. Classify a variable as either discrete or continuous and as either categorical or quantitative.	Identify as categorical or quantitative, and if quantitative, as discrete or continuous. (Only quantitative variables are discrete/continuous.)
4. Find measures of central tendency (mean, median, and mode) for given data.	
5. Find measures of spread (range, variance, standard deviation, and interquartile range) and outliers for given data.	
6. Find measures of position (including median, quartiles, percentiles, and standard scores) for given data.	"Standard scores"? Does this mean "z-scores"?
7. Classify a distribution as either symmetric, positively skewed, or negatively skewed.	
8. Explain the significance of the shape of a distribution.	
9. Apply the empirical rule to solve problems involving data that are distributed normally.	
10. Employ control charts to determine whether a process is in control.	

E. Demonstrate an understanding of the basic concepts of probability.	Covered in statistics.
1. Construct a sample space for an experiment and represent it as a list, chart, picture, or tree diagram.	

2. Apply counting techniques to determine the number of possible outcomes for an event.	
3. Classify events as either dependent or independent.	
4. Employ the concept of complementary sets to compute probabilities.	
5. Apply the binomial probability distribution to solve problems.	
6. Compute simple and compound probabilities, including conditional probabilities.	
7. Employ geometric probability methods in applied problems.	
8. Compare theoretical and experimental probabilities.	
9. Construct and compare theoretical and experimental probability distributions.	
10. Find the expected value of a discrete random variable and understand its meaning.	
11. Explain the law of large numbers.	
[Suggested additional standard]	Add: Normal distribution probabilities, sampling distributions, Central Limit Theorem.
[Suggested additional standard]	I would also add "Apply the Poisson probability distribution to solve problems." There seems to be nothing on continuous probability distributions. For instance, I believe students should be able to apply the normal, uniform and exponential distributions to solve problems