STATE MATCH

Michigan Content Standards and Expectations

English Language Arts, Mathematics, and Science
Grades 8–12

and

EXPLORE®, PLAN®, the ACT®, and WorkKeys®

May 2008

ACT®

About This Report

EXECUTIVE SUMMARY
(pp. 1–3)

This portion summarizes the findings of the alignment between Michigan's Content Standards and Expectations and ACT's Educational Planning and Assessment System (EPAS™) tests—EXPLORE® (8th and 9th grades), PLAN® (10th grade), and the ACT® (11th and 12th grades)—and ACT's WorkKeys® assessments (Reading for Information, Applied Mathematics, and Locating Information). It also presents ACT's involvement in meeting NCLB requirements and describes additional information about the unique programs and services ACT can provide to Michigan.

SECTION A
(pp. 5–7)

This section provides tables by content area (English Language Arts, Mathematics, and Science), listing the precise number of Michigan Content Standards and Expectations measured by ACT's EPAS tests and/or WorkKeys assessments by grade level.

SECTION B
(pp. 9–42)

All Michigan Content Standards and Expectations are listed here; each one highlighted is measured by ACT's EPAS tests and/or WorkKeys assessments. Michigan standards listed here are from the Michigan Content Standards and Expectations as presented on the Michigan Department of Education's website in March 2008. Underlined science content indicates that the content topics are included in, but not directly measured by, ACT's EPAS Science tests.

SECTION C
(pp. 43–52)

ACT's College Readiness Standards appear here. Highlighting indicates that a statement reflects one or more statements in the Michigan Content Standards and Expectations. College Readiness Standards not highlighted are not addressed in the Michigan Content Standards and Expectations.

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SECTION D
(pp. 53–54)

WorkKeys Level Skills appear here. Highlighting indicates that a statement reflects one or more statements in the Michigan Content Standards and Expectations. Level Skills not highlighted are not addressed in the Michigan Content Standards and Expectations.

A supplement is available that identifies the specific ACT College Readiness Standard(s) and WorkKeys Skill(s) corresponding to each Michigan Content Standard and Expectation in a side-by-side format. To request this supplement, please e-mail ACT at **statematch@act.org**.

Executive Summary

We at ACT believe our programs offer many advantages to Michigan students and educators, and this report offers strong evidence for this belief. This alignment analysis clearly answers four critical questions:

1. To what extent do ACT's Educational Planning and Assessment System (EPAS™) tests—EXPLORE® (8th and 9th grades), PLAN® (10th grade), and the ACT® (11th and 12th grades)—and ACT's WorkKeys® assessments (Reading for Information, Applied Mathematics, and Locating Information) measure Michigan's Content Standards and Expectations?
2. Can the results from ACT's testing programs be used to meet Michigan's NCLB requirement?
3. Why should Michigan choose EPAS?
4. Why choose to include WorkKeys assessments?

ACT'S TESTS MEASURE MANY IMPORTANT MICHIGAN CONTENT STANDARDS AND EXPECTATIONS IN ENGLISH LANGUAGE ARTS, MATHEMATICS, AND SCIENCE.

1. Match Results: Comparisons conducted by our content specialists show that ACT's Reading, English, Writing, Mathematics, and Science tests and WorkKeys Reading for Information and Applied Mathematics assessments measure most of Michigan's English Language Arts, Mathematics, and Science Content Standards and Expectations. WorkKeys Locating Information assessment measures some skills listed in Michigan's Science Standards:

- English Language Arts Grade 8: 2 out of 4 Strands
  High School: 4 out of 4 Strands

  Most of Michigan's Reading and Writing Content Standards and Expectations are covered by ACT's English, Reading, and Writing tests and WorkKeys Reading for Information (RI) assessment.

- Mathematics Grade 8: 4 out of 4 Strands
  High School: 4 out of 4 Strands

  Almost all of Michigan's Mathematics Content Standards and Expectations are covered by ACT's Mathematics tests and WorkKeys Applied Mathematics (AM) assessment.

- Science: Process Standards: 8 out of 8
  (Content Standards: 142 out of 142)

  All of Michigan's Science Content Standards and Expectations are covered by ACT's Science tests and WorkKeys Locating Information (LI) assessment.

  (A note about science content: ACT's Science tests present content from biology, chemistry, physics, and Earth/space sciences. Although content knowledge in these content areas is needed to answer some of the test questions, the test questions emphasize scientific reasoning and are based in experimental science contexts. Factual content knowledge, although needed to answer some of the test questions, is not systematically sampled from the full content knowledge domain. Therefore, each ACT Science Test covers some, but not all, of the discrete science content knowledge specifically described in the Michigan Science Content Standards and Expectations.

  To emphasize the point that content is included, but not necessarily covered in its entirety, on every test form, science content match results appear in parentheses in Section A of this document (which describes the number of Michigan standards measured by ACT's tests), and

STATES CHOOSE ACT BECAUSE:

- STUDENT MOTIVATION IS HIGH.
- ACT'S IS THE ONLY CURRICULUM-BASED ASSESSMENT SYSTEM THAT MEASURES STUDENT READINESS ALONG A CONTINUUM OF EMPIRICALLY DERIVED COLLEGE READINESS BENCHMARKS.
- EPAS DATA PROVIDE HELPFUL FEEDBACK FOR TEACHERS, STUDENTS, AND POLICYMAKERS TO MAKE EDUCATIONAL DECISIONS AND IDENTIFY WAYS TO IMPROVE.

ACT BUILDS ITS DEFINITION OF COLLEGE READINESS ON A SOUND EMPIRICAL BASE:

1. THE ACT NATIONAL CURRICULUM SURVEY
2. ACT'S COLLEGE READINESS BENCHMARK SCORES
3. ACT'S COLLEGE READINESS STANDARDS™

are underlined rather than highlighted in Section B. Our goal here is to clearly communicate that science content will be included, but each specific content topic will not be covered consistently enough for inferences to be made about student proficiency in all areas.)

Most exceptions to a match between ACT's tests and Michigan's Content Standards and Expectations arise from standards not being assessable in group settings, standards that are personal in nature, and standards requiring measurement over extended time. If additional testing is deemed necessary, ACT would be interested in working with Michigan on developing any necessary augmentation.

2. NCLB requirement? Yes; states like Michigan and Illinois use ACT components as part of testing that is submitted to the U.S. Department of Education for NCLB approval.

3. Why choose ACT? States and school districts choose ACT's EPAS programs because student motivation is high, and EPAS is the *only curriculum-based assessment system that measures student readiness along a continuum of empirically derived college readiness benchmarks*. Various groups claim to describe what students truly need to know and be able to do for college and/or workplace readiness. Such groups typically ask individual experts in education to gather and discuss what they feel is important for students to understand. Not surprisingly, the answers vary. In contrast, ACT defines college readiness through a unique and rigorous empirical process:

- **The knowledge and skills necessary for students to be ready for college-level work are empirically identified via the ACT National Curriculum Survey®.**

  ACT surveys thousands of secondary and postsecondary instructors across the nation to determine which skills and knowledge are most important at each course level and for college and work readiness. The responses drive the test specifications for EXPLORE, PLAN, and the ACT.

- **The empirically derived performance levels necessary for students to be ready to succeed in college-level work are defined in ACT's College Readiness Benchmark Scores.**

  ACT analyzed thousands of student records to identify the ACT scores associated with success in postsecondary coursework (i.e., a 50% chance of earning a B or better in credit-bearing first-year college courses): 18 for English, 22 for Math, 21 for Reading, and 24 for Science.

- **Skills and knowledge a student currently has and areas for improvement can be identified by the empirically derived ACT College Readiness Standards.**

  Using thousands of student records and responses, content and measurement experts at ACT have developed detailed statements that describe what students typically know and are able to do at different levels of test performance. These data-driven, empirically derived score descriptors

articulate student achievement within various score ranges on the English, Reading, Writing, Mathematics, and Science tests on the EXPLORE, PLAN, and ACT. These statements provide specific details about students' college readiness and can be used to identify next steps for improvement.

4. Why choose to include WorkKeys assessments? Students can use WorkKeys to help determine the skill levels and education required for various jobs. Educators can use WorkKeys to ensure that students enter the work world with the foundational skills needed in any field they choose.

Further, the WorkKeys scores offer a clear way for students to demonstrate their knowledge and skills to prospective employers. WorkKeys is at the center of the nationwide Career Readiness System that links qualified individuals with employers who recognize the value of skilled job applicants. ACT's National Career Readiness Certificate (NCRC) ensures that an individual has certain foundational skills that are important across a range of positions. The NCRC is a portable credential that employees can use anywhere in the nation. Individuals seeking employment gain a competitive edge with an NCRC because they are able to provide prospective employers with clear evidence that their knowledge and skills align with the requirements of the job they are applying for. The NCRC offers job seekers, employers, and educators an easily understood, conveniently attained, and universally valued credential.

Test takers are most commonly certified in the skills areas of Applied Mathematics, Locating Information, and Reading for Information. Higher scores qualify students for more jobs than do lower scores. New Jersey, Virginia, Louisiana, Kentucky, North Carolina, and New Mexico have already initiated certificate programs, and many other states are in the process of developing similar programs.

In sum, ACT's EPAS and WorkKeys programs provide abundant data regarding student readiness for college and work. This information can help Michigan educators and students make well-informed decisions in planning students' career and academic goals.

Section A: Number of Michigan Content Standards and Expectations Measured by EXPLORE, PLAN, the ACT, and WorkKeys

Table A-1. Number of Michigan English Language Arts Standards Measured by EXPLORE, PLAN, the ACT, and WorkKeys

Michigan Strands*	Number of Michigan Standards Measured by ACT's tests	Aspects of Michigan Standards that are Not Measured
Reading	Grade 8: 6 out of 9	Explain how authors use text features Monitor reading comprehension skills Feel enthusiastic about reading
Writing	Grade 8: 2 out of 7	Write a cohesive narrative piece Formulate research questions Write neat and legible compositions
Speaking	Grade 8: 0 out of 2	Speak effectively Discuss written narratives
Listening and Viewing	Grade 8: 0 out of 2	Listen to or view critically speeches and presentations
TOTALS 2 out of 4 Strands	Grade 8: 8 out of 20	
Writing, Speaking, and Visual Expression	Grades 9–12: 3 out of 5	Use prewriting strategies Recognize the role of research as a contribution to collective knowledge
Reading, Listening, and Viewing	Grades 9–12: 1 out of 3	Recognize the conventions of multimedia presentations Reflect on personal understanding of reading, listening, and viewing
Literature and Culture	Grades 9–12: 1 out of 4	Recognize a variety of literary genres and forms
Language	Grades 9–12: 1 out of 2	Understand how languages and dialects are used to communicate effectively in different roles
TOTALS 4 out of 4 Strands	Grades 9–12: 6 out of 14	

*Refer to Michigan's English Language Arts Content Standards and Expectations on pages 9–16

Table A-2. Number of Michigan Mathematics Standards Measured by EXPLORE, PLAN, the ACT, and WorkKeys					
Michigan Strands*	**Number of Michigan Standards Measured by ACT's tests**				**Aspects of Michigan Standards that are Not Measured**
Number and Operations	Grade 8:	2	out of	2	
Algebra	Grade 8:	4	out of	4	
Geometry	Grade 8:	5	out of	5	
Data and Probability	Grade 8:	2	out of	2	
TOTALS 4 out of 4 Strands	Grade 8:	13	out of	13	
Quantitative Literacy and Logic	Grades 9–12:	3	out of	3	
Algebra and Functions	Grades 9–12:	3	out of	3	
Geometry and Trigonometry	Grades 9–12:	3	out of	3	
Statistics and Probability	Grades 9–12:	3	out of	4	
TOTALS 4 out of 4 Strands	Grades 9–12:	12	out of	13	

*Refer to Michigan's Mathematics Content Standards and Expectations on pages 17–24

Table A-3. Number of Michigan Science Standards Measured by EXPLORE, PLAN, the ACT, and WorkKeys						
Michigan Disciplines*	**Number of Michigan Standards Measured by ACT's tests**					**Aspects of Michigan Standards that are Not Measured**
Earth Systems	E1:	2	out of	2		
Biology	B1:	2	out of	2		
Chemistry	C1:	2	out of	2		
Physics	P1:	2	out of	2		
TOTALS 4 out of 4 Disciplines	**Process Standards**	8	out of	8		
Earth Systems	E2: E3: E4: E5:	(4) (7) (6) (7)	out of out of out of out of	(4) (7) (6) (7)		
Biology	B2: B3: B4: B5:	(15) (11) (7) (5)	out of out of out of out of	(15) (11) (7) (5)		
Physics	P2: P3: P4:	(3) (11) (20)	out of out of out of	(3) (11) (20)		
Chemistry	C2: C3: C4: C5:	(7) (8) (17) (13)	out of out of out of out of	(7) (9) (17) (13)		
TOTALS 15 out of 15 Disciplines	**Content Standards**	(142)	out of	(142)		

*Refer to Michigan's Science Content Standards and Expectations on pages 25–42

English Language Arts

Michigan Grade 8 English Language Arts
Grade Level Content Expectations

READING

Word Recognition and Word Study

Word Recognition

R.WS.08.01 Students will explain and use word structure, sentence structure, and prediction to aid in decoding and understanding the meanings of words encountered in context.

R.WS.08.02 Students will use structural, syntactic, and semantic analysis to recognize unfamiliar words in context including idioms, analogies, metaphors, and similes to infer the history of the English language, and common word origins.

R.WS.08.03 Students will automatically recognize frequently encountered words in print with the number of words that can be read fluently increasing steadily across the school year.

R.WS.08.04 Students will know the meanings of words encountered frequently in grade-level reading and oral language contexts.

R.WS.08.05 Students will acquire and apply strategies to identify unknown words and construct meaning.

Fluency

R.WS.08.06 Students will fluently read beginning grade-level text and increasingly demanding texts as the year proceeds.

Vocabulary

R.WS.08.07 Students will in context, determine the meaning of words and phrases including content area vocabulary and literary terms using strategies including activating prior knowledge, using text features/structures, and authentic content-related resources.

Narrative Text

R.NT.08.01 Students will investigate various examples of distortion and stereotypes such as those associated with gender, race, culture, age, class, religion, and other individual differences through classic, multicultural, and contemporary literature recognized for quality and literary merit.

R.NT.08.02 Students will analyze the structure, elements, style, and purpose of narrative genre including historical fiction, science fiction, and realistic fiction.

R.NT.08.03 Students will analyze the role of rising and falling actions, minor characters in relation to conflict, and credibility of the narrator.

R.NT.08.04 Students will analyze author's craft including symbolism, imagery, and consistency to develop credible narrators, rising and falling actions, and minor characters.

Informational Text

R.IT.08.01 Students will analyze the structure, elements, features, style, and purpose of informational genre including comparative essays, newspaper writings, technical writings, and persuasive essays.

R.IT.08.02 Students will analyze organizational patterns including chronological sequence, compare/contrast, and cause/effect.

R.IT.08.03 Students will explain how authors use text features including graphics, author's pages, prefaces, and marginal notes, to enhance the understanding of central, key, and supporting ideas.

Comprehension

R.CM.08.01 Students will connect personal knowledge, experiences, and understanding of the world to themes and perspectives in text through oral and written responses.

R.CM.08.02 Students will retell through concise summarization grade-level narrative and informational text.

R.CM.08.03 Students will analyze global themes, universal truths, and principles within and across texts to create a deeper understanding by drawing conclusions, making inferences, and synthesizing.

R.CM.08.04 Students will apply significant knowledge from grade-level science, social studies, and mathematics texts.

Metacognition

R.MT.08.01 Students will self-monitor comprehension when reading or listening to text by automatically applying and discussing the strategies used by mature readers to increase comprehension including: predicting, constructing mental images, visually representing ideas in text, questioning, rereading or listening again if uncertain about meaning, inferring, summarizing, and engaging in interpretive discussions.

R.MT.08.02 Students will plan, monitor, regulate, and evaluate skills, strategies, and processes for their own reading comprehension by applying appropriate metacognitive skills.

Critical Standards

R.CS.08.01 Students will evaluate the appropriateness of shared, individual and expert standards based on purpose, context, and audience in order to assess their own writing and the writing of others.

Reading Attitude

R.AT.08.01 Students will be enthusiastic about reading and do substantial reading and writing on their own.

WRITING

Writing Genres

W.GN.08.01 Students will write a cohesive narrative piece such as poetry, historical fiction, science fiction, or realistic fiction that includes appropriate conventions to genre employing literary and plot devices (e.g., narrator credibility, rising and falling actions and/or conflict, imagery and transitional language).

W.GN.08.02 Students will write an historical expository piece such as a journal, biography, or simulated memoir that includes appropriate organization, illustrations, marginal notes and/or annotations.

W.GN.08.03 Students will formulate research questions that demonstrate critical evaluation of multiple resources, perspectives, and arguments/counter-arguments that culminate in a presented final project using the writing process.

Writing Process

W.PR.08.01 Students will set a purpose, consider audience, and replicate authors' styles and patterns when writing a narrative or informational piece.

W.PR.08.02 Students will apply a variety of pre-writing strategies for both narrative (e.g., graphic organizers designed to depict rising and falling actions, roles of minor characters, credibility of narrator) and informational writing (e.g., compare/contrast, cause/effect, or sequential text patterns).

W.PR.08.03 Students will draft focused ideas experimenting with various ways of sequencing information including ordering arguments, or sequencing ideas chronologically by importance when writing compositions.

W.PR.08.04 Students will revise drafts for coherence and consistency in word choice, structure, and style; and read their own work from another reader's perspective.

W.PR.08.05 Students will proofread and edit writing using grade-level checklists and other appropriate resources both individually and in groups.

Personal Style

W.PS.08.01 Students will exhibit personal style and voice to enhance the written message in both narrative (e.g., personification, humor, element of surprise) and informational writing (e.g., emotional appeal, strong opinion, credible support).

Grammar and Usage

W.GR.08.01 Students will in the context of writing, correctly use style conventions (e.g., Modern Language Association Handbook) and a variety of grammatical structures in compositions including infinitives, gerunds, participial phrases, and dashes or ellipses.

Spelling

W.SP.08.01 Students will in the context of writing use correct spelling conventions.

Handwriting

W.HW.08.01 Students will write neat and legible compositions.

Writing Attitude

W.AT.08.01 Students will be enthusiastic about writing and learning to write.

SPEAKING

Conventions

S.CN.08.01 Students will adjust their use of language to communicate effectively with a variety of audiences and for different purposes by using enunciation to emphasize key ideas and concepts when presenting.

S.CN.08.02 Students will speak effectively using body language including gestures, posture, facial expressions, tone of voice, and pace of speaking to enhance meaning and influence interpretation in narrative and informational presentations.

S.CN.08.03 Students will present in standard American English if it is their first language. (Students whose first language is not English will present in their developing version of standard American English.)

Discourse

S.DS.08.01 Students will engage in interactive, extended discourse to socially construct meaning in book clubs, literature circles, partnerships, or other conversation protocols.

S.DS.08.02 Students will respond to multiple text types in order to explore problems and pose solutions supported with evidence, take a stand on an issue and support it, and identify personally with a universal theme.

S.DS.08.03 Students will discuss written narratives with a variety of literary and plot devices (e.g., description of relevant situations, well-chosen details, relevant dialogue, specific action, and physical description of characters).

S.DS.08.04 Students will plan, outline, and deliver an informational presentation using precise and vivid language in the active voice; organizing logically to convey the message; applying persuasive non-verbal techniques; making use of rhetorical strategies to support the purpose of the presentation and to positively impact the intended audience.

LISTENING & VIEWING

Conventions

L.CN.08.01 Students will analyze main idea, significant details, fact and opinion, bias, propaganda, argumentation, or support when listening to or viewing a variety of speeches and presentations.

L.CN.08.02 Students will listen to or view critically while demonstrating appropriate social skills of audience behaviors (e.g., eye contact, attentive, and supportive); critically examine the verbal and non-verbal strategies during speeches and presentations.

Response

L.RP.08.01 Students will listen to or view knowledgeably a variety of genre to react to a speaker's intent and apply a speaker's reasoning to other situations.

L.RP.08.02 Students will select, listen to or view knowledgeably, respond thoughtfully to both classic and contemporary texts recognized for quality and literary merit.

L.RP.08.03 Students will paraphrase a speaker's main ideas, purpose, and point of view, and ask relevant questions about the content, delivery, and purpose of the presentation.

L.RP.08.04 Students will analyze oral interpretations of literature (e.g., language choice, delivery) and the effect of the interpretations on the listener.

L.RP.08.05 Students will respond to multiple text types when listened to or viewed knowledgeably, by discussing, illustrating, and/or writing in order to anticipate and answer questions; determine personal and universal themes; and offer opinions or solutions.

L.RP.08.06 Students will evaluate the credibility of a speaker by determining whether the speaker may have hidden agendas or be otherwise biased.

L.RP.08.07 Students will interpret and analyze the various ways in which visual image-makers (e.g., graphic artists, illustrators) communicate information and affect impressions and opinions.

STRAND 1: WRITING, SPEAKING, AND VISUAL EXPRESSION

STANDARD 1.1

Understand and practice writing as a recursive process.

CE 1.1.1 Demonstrate flexibility in using independent and collaborative strategies for planning, drafting, revising, and editing complex texts.

CE 1.1.2 Know and use a variety of prewriting strategies to generate, focus, and organize ideas (e.g., free writing, clustering/mapping, talking with others, brainstorming, outlining, developing graphic organizers, taking notes, summarizing, paraphrasing).

CE 1.1.3 Select and use language that is appropriate (e.g., formal, informal, literary, or technical) for the purpose, audience, and context of the text, speech, or visual representation (e.g., letter to editor, proposal, poem, or digital story).

CE 1.1.4 Compose drafts that convey an impression, express an opinion, raise a question, argue a position, explore a topic, tell a story, or serve another purpose, while simultaneously considering the constraints and possibilities (e.g., structure, language, use of conventions of grammar, usage, and mechanics) of the selected form or genre.

CE 1.1.5 Revise drafts to more fully and/or precisely convey meaning—drawing on response from others, self-reflection, and reading one's own work with the eye of a reader; then refine the text—deleting and/or reorganizing ideas, and addressing potential readers' questions.

CE 1.1.6 Reorganize sentence elements as needed and choose grammatical and stylistic options that provide sentence variety, fluency, and flow.

CE 1.1.7 Edit for style, tone, and word choice (specificity, variety, accuracy, appropriateness, conciseness) and for conventions of grammar, usage and mechanics that are appropriate for audience.

CE 1.1.8 Proofread to check spelling, layout, and font; and prepare selected pieces for a public audience.

STANDARD 1.2

Use writing, speaking, and visual expression for personal understanding and growth.

CE 1.2.1 Write, speak, and use images and graphs to understand and discover complex ideas.

CE 1.2.2 Write, speak, and visually represent to develop self-awareness and insight (e.g., diary, journal writing, portfolio self-assessment).

CE 1.2.3 Write, speak, and create artistic representations to express personal experience and perspective (e.g., personal narrative, poetry, imaginative writing, slam poetry, blogs, webpages).

CE 1.2.4 Assess strengths, weaknesses, and development as a writer by examining a collection of own writing.

STANDARD 1.3

Communicate in speech, writing, and multimedia using content, form, voice, and style appropriate to the audience and purpose (e.g., to reflect, persuade, inform, analyze, entertain, inspire).

CE 1.3.1 Compose written, spoken, and/or multimedia compositions in a range of genres (e.g., personal narrative, biography, poem, fiction, drama, creative nonfiction, summary, literary analysis essay, research report, or work-related text): pieces that serve a variety of purposes (e.g., expressive, informative, creative, and persuasive) and that use a variety of organizational patterns (e.g., autobiography, free verse, dialogue, comparison/contrast, definition, or cause and effect).

CE 1.3.2 Compose written and spoken essays or work-related text that demonstrate logical thinking and the development of ideas for academic, creative, and personal purposes: essays that convey the author's message by using an engaging introduction (with a clear thesis as appropriate), well-constructed paragraphs, transition sentences, and a powerful conclusion.

CE 1.3.3 Compose essays with well-crafted and varied sentences demonstrating a precise, flexible, and creative use of language.

CE 1.3.4 Develop and extend a thesis, argument, or exploration of a topic by analyzing differing perspectives and employing a structure that effectively conveys the ideas in writing (e.g. resolve inconsistencies in logic; use a range of strategies to persuade, clarify, and defend a position with precise and relevant evidence; anticipate and address concerns and counterclaims; provide a clear and effective conclusion).

CE 1.3.5 From the outset, identify and assess audience expectations and needs; consider the rhetorical effects of style, form, and content based on that assessment; and adapt communication strategies appropriately and effectively.

CE 1.3.6 Use speaking, writing, and visual presentations to appeal to audiences of different social, economic, and cultural backgrounds and experiences (e.g., include explanations and definitions according to the audience's background, age, or knowledge of the topic; adjust formality of style; consider interests of potential readers).

CE 1.3.7 Participate collaboratively and productively in groups (e.g., response groups, work teams, discussion groups, and committees)—fulfilling roles and responsibilities, posing relevant questions, giving and following instructions, acknowledging and building on ideas and contributions of others to answer questions or to solve problems, and offering dissent courteously.

CE 1.3.8 Evaluate own and others' effectiveness in group discussions and formal presentations (e.g., considering accuracy, relevance, clarity, and delivery; types of arguments used; and relationships among purpose, audience, and content).

CE 1.3.9 Use the formal, stylistic, content, and mechanical conventions of a variety of genres in speaking, writing, and multimedia presentations.

STANDARD 1.4

Develop and use the tools and practices of inquiry and research—generating, exploring, and refining important questions; creating a hypothesis or thesis; gathering and studying evidence; drawing conclusions; and composing a report.

CE 1.4.1 Identify, explore, and refine topics and questions appropriate for research.

CE 1.4.2 Develop a system for gathering, organizing, paraphrasing, and summarizing information; select, evaluate, synthesize, and use multiple primary and secondary (print and electronic) resources.

CE 1.4.3 Develop and refine a position, claim, thesis, or hypothesis that will be explored and supported by analyzing different perspectives, resolving inconsistencies, and writing about those differences in a structure appropriate for the audience (e.g., argumentative essay that avoids inconsistencies in logic and develops a single thesis; exploratory essay that explains differences and similarities and raises additional questions).

CE 1.4.4 Interpret, synthesize, and evaluate information/findings in various print sources and media (e.g., fact and opinion, comprehensiveness of the evidence, bias, varied perspectives, motives and credibility of the author, date of publication) to draw conclusions and implications.

CE 1.4.5 Develop organizational structures appropriate to the purpose and message, and use transitions that produce a sequential or logical flow of ideas.

CE 1.4.6 Use appropriate conventions of textual citation in different contexts (e.g., different academic disciplines and workplace writing situations).

CE 1.4.7 Recognize the role of research, including student research, as a contribution to collective knowledge, selecting an appropriate method or genre through which research findings will be shared and evaluated, keeping in mind the needs of the prospective audience. (e.g., presentations, online sharing, written products such as a research report, a research brief, a multi-genre report, I-Search, literary analysis, news article).

STANDARD 1.5

Produce a variety of written, spoken, multigenre, and multimedia works, making conscious choices about language, form, style, and/or visual representation for each work (e.g., poetry, fiction and creative nonfiction stories, academic and literary essays, proposals, memos, manifestos, business letters, advertisements, prepared speeches, group and dramatic performances, poetry slams, and digital stories).

CE 1.5.1 Use writing, speaking, and visual expression to develop powerful, creative and critical messages.

CE 1.5.2 Prepare spoken and multimedia presentations that effectively address audiences by careful use of voice, pacing, gestures, eye contact, visual aids, audio and video technology.

CE 1.5.3 Select format and tone based on the desired effect and audience, using effective written and spoken language, sound, and/or visual representations (e.g., focus, transitions, facts, detail and evidence to support judgments, skillful use of rhetorical devices, and a coherent conclusion).

CE 1.5.4 Use technology tools (e.g, word processing, presentation and multimedia software) to produce polished written and multimedia work (e.g., literary and expository works, proposals, business presentations, advertisements).

CE 1.5.5 Respond to and use feedback to strengthen written and multimedia presentations (e.g., clarify and defend ideas, expand on a topic, use logical arguments, modify organization, evaluate effectiveness of images, set goals for future presentations).

STRAND 2: READING, LISTENING, AND VIEWING

STANDARD 2.1

Develop critical reading, listening, and viewing strategies.

CE 2.1.1 Use a variety of pre-reading and previewing strategies (e.g., acknowledge own prior knowledge, make connections, generate questions, make predictions, scan a text for a particular purpose or audience, analyze text structure and features) to make conscious choices about how to approach the reading based on purpose, genre, level of difficulty, text demands and features.

CE 2.1.2 Make supported inferences and draw conclusions based on informational print and multimedia features (e.g., prefaces, appendices, marginal notes, illustrations, bibliographies, author's pages, footnotes, diagrams, tables, charts, maps, timelines, graphs, and other visual and special effects) and explain how authors and speakers use them to infer the organization of text and enhance understanding, convey meaning, and inspire or mislead audiences.

CE 2.1.3 Determine the meaning of unfamiliar words, specialized vocabulary, figurative language, idiomatic expressions, and technical meanings of terms through context clues, word roots and affixes, and the use of appropriate resource materials such as print and electronic dictionaries.

CE 2.1.4 Identify and evaluate the primary focus, logical argument, structure, and style of a text or speech and the ways in which these elements support or confound meaning or purpose.

CE 2.1.5 Analyze and evaluate the components of multiple organizational patterns (e.g., compare/contrast, cause/effect, problem/solution, fact/opinion, theory/evidence).

CE 2.1.6 Recognize the defining characteristics of informational texts, speeches, and multimedia presentations (e.g., documentaries and research presentations) and elements of expository texts (e.g., thesis, supporting ideas, and statistical evidence); critically examine the argumentation and conclusions of multiple informational texts.

CE 2.1.7 Demonstrate understanding of written, spoken, or visual information by restating, paraphrasing, summarizing, critiquing, or composing a personal response; distinguish between a summary and a critique.

CE 2.1.8 Recognize the conventions of visual and multimedia presentations (e.g., lighting, camera angle, special effects, color, and soundtrack) and how they carry or influence messages.

CE 2.1.9 Examine the intersections and distinctions between visual (media images, painting, film, and graphic arts) and verbal communication.

CE 2.1.10 Listen to and view speeches, presentations, and multimedia works to identify and respond thoughtfully to key ideas, significant details, logical organization, fact and opinion, and propaganda.

CE 2.1.11 Demonstrate appropriate social skills of audience, group discussion, or work team behavior by listening attentively and with civility to the ideas of others, gaining the floor in respectful ways, posing appropriate questions, and tolerating ambiguity and lack of consensus.

CE 2.1.12 Use a variety of strategies to enhance listening comprehension (e.g., monitor message for clarity and understanding, ask relevant questions, provide verbal and nonverbal feedback, notice cues such as change of pace or emphasis that indicate a new point is about to be made; and take notes to organize essential information).

STANDARD 2.2

Use a variety of reading, listening, and viewing strategies to construct meaning beyond the literal level (e.g., drawing inferences; confirming and correcting; making comparisons, connections, and generalizations; and drawing conclusions).

CE 2.2.1 Recognize literary and persuasive strategies as ways by which authors convey ideas and readers make meaning (e.g., imagery, irony, satire, parody, propaganda, overstatement/understatement, omission, and multiple points of view).

CE 2.2.2 Examine the ways in which prior knowledge and personal experience affect the understanding of written, spoken, or multimedia text.

CE 2.2.3 Interpret the meaning of written, spoken, and visual texts by drawing on different cultural, theoretical, and critical perspectives.

STANDARD 2.3

Develop as a reader, listener, and viewer for personal, social, and political purposes, through independent and collaborative reading.

CE 2.3.1 Read, listen to, and view diverse texts for multiple purposes such as learning complex procedures, making work-place decisions, or pursuing in-depth studies.

CE 2.3.2 Read, view, and/or listen independently to a variety of fiction, nonfiction, and multimedia genres based on student interest and curiosity.

CE 2.3.3 Critically read and interpret instructions for a variety of tasks (e.g., completing assignments, using software, writing college and job applications).

CE 2.3.4 Critically interpret primary and secondary research-related documents (e.g., historical and government documents, newspapers, critical and technical articles, and subject-specific books).

CE 2.3.5 Engage in self-assessment as a reader, listener, and viewer, while monitoring comprehension and using a variety of strategies to overcome difficulties when constructing and conveying meaning.

CE 2.3.6 Reflect on personal understanding of reading, listening, and viewing; set personal learning goals; and take responsibility for personal growth.

CE 2.3.7 Participate as an active member of a reading, listening, and viewing community, collaboratively selecting materials to read or events to view and enjoy (e.g., book talks, literature circles, film clubs).

CE 2.3.8 Develop and apply personal, shared, and academic criteria to evaluate own and others' oral, written, and visual texts.

STRAND 3: LITERATURE AND CULTURE

STANDARD 3.1

Develop the skills of close and contextual literary reading.

CE 3.1.1 Interpret literary language (e.g., imagery, allusions, symbolism, metaphor) while reading literary and expository works.

CE 3.1.2 Demonstrate an understanding of literary characterization, character development, the function of major and minor characters, motives and causes for action, and moral dilemmas that characters encounter by describing their function in specific works.

CE 3.1.3 Recognize a variety of plot structures and elements (e.g., story within a story, rising action, foreshadowing, flash backs, cause-and-effect relationships, conflicts, resolutions) and describe their impact on the reader in specific literary works.

CE 3.1.4 Analyze characteristics of specific works and authors (e.g., voice, mood, time sequence, author vs. narrator, stated vs. implied author, intended audience and purpose, irony, parody, satire, propaganda, use of archetypes and symbols) and identify basic beliefs, perspectives, and philosophical assumptions underlying an author's work.

CE 3.1.5 Comparatively analyze two or more literary or expository texts, comparing how and why similar themes are treated differently, by different authors, in different types of text, in different historical periods, and/or from different cultural perspectives.

CE 3.1.6 Examine differing and diverse interpretations of literary and expository works and explain how and why interpretation may vary from reader to reader.

CE 3.1.7 Analyze and evaluate the portrayal of various groups, societies, and cultures in literature and other texts.

CE 3.1.8 Demonstrate an understanding of historical, political, cultural, and philosophical themes and questions raised by literary and expository works.

CE 3.1.9 Analyze how the tensions among characters, communities, themes, and issues in literature and other texts reflect human experience.

CE 3.1.10 Demonstrate an understanding of the connections between literary and expository works, themes, and historical and contemporary contexts.

STANDARD 3.2

Read and respond to classic and contemporary fiction, literary nonfiction, and expository text, from a variety of literary genres representing many time periods and authors (e.g., myth, epic, folklore, drama, poetry, autobiography, novels, short stories, philosophical pieces, science fiction, fantasy, young adult literature, creative non-fiction, hypertext fiction).

CE 3.2.1 Recognize a variety of literary genres and forms (e.g., poetry, drama, novels, short stories, autobiographies, biographies, multi-genre texts, satire, parody, allegory) and demonstrate an understanding of the way in which genre and form influence meaning.

CE 3.2.2 Identify different types of poetry (e.g., epic, lyric, sonnet, free verse) and explain how specific features (e.g., figurative language, imagery, rhythm, alliteration, etc.) influence meaning.

CE 3.2.3 Identify how elements of dramatic literature (e.g., dramatic irony, soliloquy, stage direction, and dialogue) illuminate the meaning of the text.

CE 3.2.4 Respond by participating actively and appropriately in small and large group discussions about literature (e.g., posing questions, listening to others, contributing ideas, reflecting on and revising initial responses).

CE 3.2.5 Respond to literature in a variety of ways (e.g., dramatic interpretation, reader's theatre, literature circles, illustration, writing in a character's voice, engaging in social action, writing an analytic essay) providing examples of how texts affect their lives, connect them with the contemporary world, and communicate across time.

STANDARD 3.3

Use knowledge of literary history, traditions, and theory to respond to and analyze the meaning of texts.

CE 3.3.1 Explore the relationships among individual works, authors, and literary movements in English and American literature (e.g., Romanticism, Puritanism, the Harlem Renaissance, Postcolonial), and consider the historical, cultural, and societal contexts in which works were produced.

CE 3.3.2 Read and analyze classic and contemporary works of literature (American, British, world) representing a variety of genres and traditions and consider their significance in their own time period as well as how they may be relevant to contemporary society.

CE 3.3.3 Draw on a variety of critical perspectives to respond to and analyze works of literature (e.g., religious, biographical, feminist, multicultural, political).

CE 3.3.4 Demonstrate knowledge of American minority literature and the contributions of minority writers.

CE 3.3.5 Demonstrate familiarity with world literature, including authors beyond American and British literary traditions.

CE 3.3.6 Critically examine standards of literary judgment (e.g., aesthetic value, quality of writing, literary merit, social significance) and questions regarding the inclusion and/or exclusion of literary works in the curriculum (e.g., canon formation, "classic" vs. "popular" texts, traditional vs. non-traditional literature, the place of literature by women and/or minority writers).

STANDARD 3.4

Examine mass media, film, series fiction, and other texts from popular culture.

CE 3.4.1 Use methods of close and contextualized reading and viewing to examine, interpret, and evaluate print and visual media and other works from popular culture.

CE 3.4.2 Understand that media and popular texts are produced within a social context and have economic, political, social, and aesthetic purposes.

CE 3.4.3 Understand the ways people use media in their personal and public lives.

CE 3.4.4 Understand how the commercial and political purposes of producers and publishers influence not only the nature of advertisements and the selection of media content, but the slant of news articles in newspapers, magazines, and the visual media.

STRAND 4: LANGUAGE

STANDARD 4.1

Understand and use the English language effectively in a variety of contexts and settings.

CE 4.1.1 Use sentence structures and vocabulary effectively within different modes (oral and written, formal and informal) and for various rhetorical purposes.

CE 4.1.2 Use resources to determine word meanings, pronunciations, and word etymologies (e.g., context, print and electronic dictionaries, thesauruses, glossaries, and others).

CE 4.1.3 Use a range of linguistic applications and styles for accomplishing different rhetorical purposes (e.g., persuading others to change opinions, conducting business transactions, speaking in a public forum, discussing issues informally with peers).

CE 4.1.4 Control standard English structures in a variety of contexts (e.g., formal speaking, academic prose, business, and public writing) using language carefully and precisely.

CE 4.1.5 Demonstrate use of conventions of grammar, usage, and mechanics in written texts, including parts of speech, sentence structure and variety, spelling, capitalization, and punctuation.

STANDARD 4.2

Understand how language variety reflects and shapes experience.

CE 4.2.1 Understand how languages and dialects are used to communicate effectively in different roles, under different circumstances, and among speakers of different speech communities (e.g., ethnic communities, social groups, professional organizations).

CE 4.2.2 Understand the implications and potential consequences of language use (e.g., appropriate professional speech; sexist, racist, homophobic language).

CE 4.2.3 Recognize and appreciate language variety, understand that all dialects are rule-governed, and respect the linguistic differences of other speech communities.

CE 4.2.4 Understand the appropriate uses and implications of casual or informal versus professional language; understand, as well, the implications of language designed to control others and the detrimental effects of its use on targeted individuals or groups (e.g., propaganda, homophobic language, and racial, ethnic, or gender epithets).

CE 4.2.5 Recognize language bias in one's community, school, textbooks, the public press, and in one's own use of language.

Michigan Grade 8 Mathematics
Content Standards and Expectations

NUMBER AND OPERATIONS

Understand real number concepts

N.ME.08.01 Understand the meaning of a square root of a number and its connection to the square whose area is the number; understand the meaning of a cube root and its connection to the volume of a cube.

N.ME.08.02 Understand meanings for zero and negative integer exponents.

N.ME.08.03 Understand that in decimal form, rational numbers either terminate or eventually repeat, and that calculators truncate or round repeating decimals; locate rational numbers on the number line; know fraction forms of common repeating decimals, e.g., $0.\overline{1} = \frac{1}{9}$; $0.\overline{3} = \frac{1}{3}$.

N.ME.08.04 Understand that irrational numbers are those that cannot be expressed as the quotient of two integers, and cannot be represented by terminating or repeating decimals; approximate the position of familiar irrational numbers, e.g., $\sqrt{2}$, $\sqrt{3}$, π, on the number line.

N.FL.08.05 Estimate and solve problems with square roots and cube roots using calculators.

N.FL.08.06 Find square roots of perfect squares and approximate the square roots of non-perfect squares by locating between consecutive integers, e.g., $\sqrt{130}$ is between 11 and 12.

Solve problems

N.MR.08.07 Understand percent increase and percent decrease in both sum and product form, e.g., 3% increase of a quantity x is $x + .03x = 1.03x$.

N.MR.08.08 Solve problems involving percent increases and decreases.

N.FL.08.09 Solve problems involving compounded interest or multiple discounts.

N.MR.08.10 Calculate weighted averages such as course grades, consumer price indices, and sports ratings.

N.FL.08.11 Solve problems involving ratio units, such as miles per hour, dollars per pound, or persons per square mile.

ALGEBRA

Understand the concept of non-linear functions using basic examples

A.RP.08.01 Identify and represent linear functions, quadratic functions, and other simple functions including inversely proportional relationships $\left(y = \frac{k}{x}\right)$; cubics ($y = ax^3$); roots ($y = \sqrt{x}$); and exponentials ($y = a^x$, $a > 0$); using tables, graphs, and equations.

A.PA.08.02 For basic functions, e.g., simple quadratics, direct and indirect variation, and population growth, describe how changes in one variable affect the others.

A.PA.08.03 Recognize basic functions in problem context, e.g., area of a circle is πr^2, volume of a sphere is $\frac{4}{3}\pi r^2$, and represent them using tables, graphs, and formulas.

A.RP.08.04 Use the vertical line test to determine if a graph represents a function in one variable.

Understand and represent quadratic functions

A.RP.08.05 Relate quadratic functions in factored form and vertex form to their graphs, and vice versa; in particular, note that solutions of a quadratic equation are the x-intercepts of the corresponding quadratic function.

A.RP.08.06 Graph factorable quadratic functions, finding where the graph intersects the x-axis and the coordinates of the vertex; use words "parabola" and "roots"; include functions in vertex form and those with leading coefficient –1, e.g., $y = x^2 - 36$, $y = (x - 2)^2 - 9$; $y = -x^2$; $y = -(x - 3)^2$.

Recognize, represent, and apply common formulas

A.FO.08.07 Recognize and apply the common formulas:
$(a + b)^2 = a^2 + 2ab + b^2$
$(a - b)^2 = a^2 - 2ab + b^2$
$(a + b)(a - b) = a^2 - b^2$; represent geometrically.

A.FO.08.08 Factor simple quadratic expressions with integer coefficients, e.g., $x^2 + 6x + 9$, $x^2 + 2x - 3$, and $x^2 - 4$; solve simple quadratic equations, e.g., $x^2 = 16$ or $x^2 = 5$ (by taking square roots); $x^2 - x - 6 = 0$, $x^2 - 2x = 15$ (by factoring); verify solutions by evaluation.

A.FO.08.09 Solve applied problems involving simple quadratic equations.

Understand solutions and solve equations, simultaneous equations, and linear inequalities

A.FO.08.10 Understand that to solve the equation $f(x) = g(x)$ means to find all values of x for which the equation is true, e.g., determine whether a given value, or values from a given set, is a solution of an equation (0 is a solution of $3x^2 + 2 = 4x + 2$, but 1 is not a solution).

A.FO.08.11 Solve simultaneous linear equations in two variables by graphing, by substitution, and by linear combination; estimate solutions using graphs; include examples with no solutions and infinitely many solutions.

A.FO.08.12 Solve linear inequalities in one and two variables, and graph the solution sets.

A.FO.08.13 Set up and solve applied problems involving simultaneous linear equations and linear inequalities.

GEOMETRY

Understand and use the Pythagorean Theorem

G.GS.08.01 Understand at least one proof of the Pythagorean Theorem; use the Pythagorean Theorem and its converse to solve applied problems including perimeter, area, and volume problems.

G.LO.08.02 Find the distance between two points on the coordinate plane using the distance formula; recognize that the distance formula is an application of the Pythagorean Theorem.

Solve problems about geometric figures

G.SR.08.03 Understand the definition of a circle; know and use the formulas for circumference and area of a circle to solve problems.

G.SR.08.04 Find area and perimeter of complex figures by sub-dividing them into basic shapes (quadrilaterals, triangles, circles).

G.SR.08.05 Solve applied problems involving areas of triangles, quadrilaterals, and circles.

Understand concepts of volume and surface area, and apply formulas

G.SR.08.06 Know the volume formulas for generalized cylinders ((area of base) × height), generalized cones and pyramids ($\frac{1}{3}$(area of base) × height), and spheres ($\frac{4}{3}\pi(\text{radius})^3$) and apply them to solve problems.

G.SR.08.07 Understand the concept of surface area, and find the surface area of prisms, cones, spheres, pyramids, and cylinders.

Visualize solids

G.SR.08.08 Sketch a variety of two-dimensional representations of three-dimensional solids including orthogonal views (top, front, and side), picture views (projective or isometric), and nets; use such two-dimensional representations to help solve problems.

Understand and apply concepts of transformation and symmetry

G.TR.08.09 Understand the definition of a dilation from a point in the plane, and relate it to the definition of similar polygons.

G.TR.08.10 Understand and use reflective and rotational symmetries of two-dimensional shapes and relate them to transformations to solve problems.

DATA AND PROBABILITY

Draw, explain, and justify conclusions based on data

D.AN.08.01 Determine which measure of central tendency (mean, median, mode) best represents a data set, e.g., salaries, home prices, for answering certain questions; justify the choice made.

D.AN.08.02 Recognize practices of collecting and displaying data that may bias the presentation or analysis.

Understand probability concepts for simple and compound events

D.PR.08.03 Compute relative frequencies from a table of experimental results for a repeated event. Interpret the results using relationship of probability to relative frequency.

D.PR.08.04 Apply the Basic Counting Principle to find total number of outcomes possible for independent and dependent events, and calculate the probabilities using organized lists or tree diagrams.

D.PR.08.05 Find and/or compare the theoretical probability, the experimental probability, and/or the relative frequency of a given event.

D.PR.08.06 Understand the difference between independent and dependent events, and recognize common misconceptions involving probability, e.g., Alice rolls a 6 on a die three times in a row; she is just as likely to roll a 6 on the fourth roll as she was on any previous roll.

STRAND 1: QUANTITATIVE LITERACY AND LOGIC

STANDARD L1: REASONING ABOUT NUMBERS, SYSTEMS, AND QUANTITATIVE SITUATIONS

L1.1 Number Systems and Number Sense

L1.1.1 Know the different properties that hold in different number systems and recognize that the applicable properties change in the transition from the positive integers to all integers, to the rational numbers, and to the real numbers.

L1.1.2 Explain why the multiplicative inverse of a number has the same sign as the number, while the additive inverse of a number has the opposite sign.

L1.1.3 Explain how the properties of associativity, commutativity, and distributivity, as well as identity and inverse elements, are used in arithmetic and algebraic calculations.

L1.1.4 Describe the reasons for the different effects of multiplication by, or exponentiation of, a positive number by a number less than 0, a number between 0 and 1, and a number greater than 1.

L1.1.5 Justify numerical relationship

L1.1.6 Explain the importance of the irrational numbers $\sqrt{2}$ and $\sqrt{3}$ in basic right triangle trigonometry, and the importance of π because of its role in circle relationships.

L1.2 Representations and Relationships

L1.2.1 Use mathematical symbols to represent quantitative relationships and situations.

L1.2.2 Interpret representations that reflect absolute value relationships in such contexts as error tolerance.

L1.2.3 Use vectors to represent quantities that have magnitude and direction, interpret direction and magnitude of a vector numerically, and calculate the sum and difference of two vectors.

L1.2.4 Organize and summarize a data set in a table, plot, chart, or spreadsheet; find patterns in a display of data; understand and critique data displays in the media.

L1.3 Counting and Probabilistic Reasoning

L1.3.1 Describe, explain, and apply various counting techniques; relate combinations to Pascal's triangle; know when to use each technique.

L1.3.2 Define and interpret commonly used expressions of probability.

L1.3.3 Recognize and explain common probability misconceptions such as "hot streaks" and "being due."

STANDARD L2: CALCULATION, ALGORITHMS, AND ESTIMATION

L2.1 Calculation Using Real and Complex Numbers

L2.1.1 Explain the meaning and uses of weighted averages.

L2.1.2 Calculate fluently with numerical expressions involving exponents; use the rules of exponents; evaluate numerical expressions involving rational and negative exponents; transition easily between roots and exponents.

L2.1.3 Explain the exponential relationship between a number and its base 10 logarithm and use it to relate rules of logarithms to those of exponents in expressions involving numbers.

L2.1.4 Know that the complex number i is one of two solutions to $x^2 = -1$.

L2.1.5 Add, subtract, and multiply complex numbers; use conjugates to simplify quotients of complex numbers.

L2.2 Sequences and Iteration

L2.2.1 Find the n^{th} term in arithmetic, geometric, or other simple sequences.

L2.2.2 Compute sums of finite arithmetic and geometric sequences.

L2.2.3 Use iterative processes in such examples as computing compound interest or applying approximation procedures.

L2.3 Measurement Units, Calculations, and Scales

L2.3.1 Convert units of measurement within and between systems; explain how arithmetic operations on measurements affect units, and carry units through calculations correctly.

L2.3.2 Describe and interpret logarithmic relationships in such contexts as the Richter scale, the pH scale, or decibel measurements; solve applied problems.

L2.4 Understanding Error

L2.4.1 Determine what degree of accuracy is reasonable for measurements in a given situation; express accuracy through use of significant digits, error tolerance, or percent of error; describe how errors in measurements are magnified by computation; recognize accumulated error in applied situations.

L2.4.2 Describe and explain round-off error, rounding, and truncating.

L2.4.3 Know the meaning of and interpret statistical significance, margin of error, and confidence level.

RECOMMENDED

L1.2.5 Read and interpret representations from various technological sources, such as contour or isobar diagrams.

L2.1.7 Understand the mathematical bases for the differences among voting procedures.

L2.2.4 Compute sums of infinite geometric sequences.

STANDARD L3: MATHEMATICAL REASONING, LOGIC, AND PROOF

L3.1 Mathematical Reasoning

L3.1.1 Distinguish between inductive and deductive reasoning, identifying and providing examples of each.

L3.1.2 Differentiate between statistical arguments (statements verified empirically using examples or data) and logical arguments based on the rules of logic.

L3.1.3 Define and explain the roles of axioms (postulates), definitions, theorems, counterexamples, and proofs in the logical structure of mathematics. Identify and give examples of each.

L3.2 Language and Laws of Logic

L3.2.1 Know and use the terms of basic logic.

L3.2.2 Use the connectives "not," "and," "or," and "if…, then," in mathematical and everyday settings. Know the truth table of each connective and how to logically negate statements involving these connectives.

L3.2.3 Use the quantifiers "there exists" and "all" in mathematical and everyday settings and know how to logically negate statements involving them.

L3.2.4 Write the converse, inverse, and contrapositive of an "if…, then…" statement. Use the fact, in mathematical and everyday settings, that the contrapositive is logically equivalent to the original, while the inverse and converse are not.

L3.3 Proof

L3.3.1 Know the basic structure for the proof of an "if…, then…" statement (assuming the hypothesis and ending with the conclusion) and that proving the contrapositive is equivalent.

L3.3.2 Construct proofs by contradiction. Use counterexamples, when appropriate, to disprove a statement.

L3.3.3 Explain the difference between a necessary and a sufficient condition within the statement of a theorem. Determine the correct conclusions based on interpreting a theorem in which necessary or sufficient conditions in the theorem or hypothesis are satisfied.

STRAND 2: ALGEBRA AND FUNCTIONS

STANDARD A1: EXPRESSIONS, EQUATIONS, AND INEQUALITIES

A1.1 Construction, Interpretation, and Manipulation of Expressions

A1.1.1 Give a verbal description of an expression that is presented in symbolic form, write an algebraic expression from a verbal description, and evaluate expressions given values of the variables.

A1.1.2 Know the definitions and properties of exponents and roots transition fluently between them, and apply them in algebraic expressions.

A1.1.3 Factor algebraic expressions using, for example, greatest common factor, grouping, and the special product identities.

A1.1.4 Add, subtract, multiply, and simplify polynomials and rational expressions.

A1.1.5 Divide a polynomial by a monomial.

A1.1.6 Transform exponential and logarithmic expressions into equivalent forms using the properties of exponents and logarithms, including the inverse relationship between exponents and logarithms.

A1.2 Solutions of Equations and Inequalities

A1.2.1 Write equations and inequalities with one or two variables to represent mathematical or applied situations, and solve.

A1.2.2 Associate a given equation with a function whose zeros are the solutions of the equation.

A1.2.3 Solve linear and quadratic equations and inequalities including systems of up to three linear equations with three unknowns. Justify steps in the solution, and apply the quadratic formula appropriately.

A1.2.4 Solve absolute value equations and inequalities, and justify steps in the solution.

A1.2.5 Solve polynomial equations and equations involving rational expressions, and justify steps in the solution.

A1.2.6 Solve power equations and equations including radical expressions, justify steps in the solution, and explain how extraneous solutions may arise.

A1.2.7 Solve exponential and logarithmic equations, and justify steps in the solution.

A1.2.8 Solve an equation involving several variables (with numerical or letter coefficients) for a designated variable. Justify steps in the solution.

A1.2.9 Know common formulas and apply appropriately in contextual situations.

A1.2.10 Use special values of the inverse trigonometric functions to solve trigonometric equations over specific intervals.

STANDARD A2: FUNCTIONS

A2.1 Definitions, Representations, and Attributes of Functions

A2.1.1 Determine whether a relationship (given in contextual, symbolic, tabular, or graphical form) is a function and identify its domain and range.

A2.1.2 Read, interpret, and use function notation and evaluate a function at a value in its domain.

A2.1.3 Represent functions in symbols, graphs, tables, diagrams, or words and translate among representations.

A2.1.4 Recognize that functions may be defined by different expressions over different intervals of their domains; such functions are piecewise-defined.

A2.1.5 Recognize that functions may be defined recursively. Compute values of and graph simple recursively defined functions.

A2.1.6 Identify the zeros of a function, the intervals where the values of a function are positive or negative, and describe the behavior of a function as *x* approaches positive or negative infinity, given the symbolic and graphical representations.

A2.1.7 Identify and interpret the key features of a function from its graph or its formula(e).

A2.2 Operations and Transformations

A2.2.1 Combine functions by addition, subtraction, multiplication, and division.

A2.2.2 Apply given transformations to basic functions and represent symbolically.

A2.2.3 Recognize whether a function (given in tabular or graphical form) has an inverse and recognize simple inverse pairs.

A2.3 Representations of Functions

A2.3.1 Identify a function as a member of a family of functions based on its symbolic or graphical representation; recognize that different families of functions have different asymptotic behavior.

A2.3.2 Describe the tabular pattern associated with functions having constant rate of change (linear); or variable rates of change.

A2.3.3 Write the general symbolic forms that characterize each family of functions.

A2.4 Models of Real-world Situations Using Families of Functions

A2.4.1 Identify the family of function best suited for modeling a given real-world situation.

A2.4.2 Adapt the general symbolic form of a function to one that fits the specification of a given situation by using the information to replace arbitrary constants with numbers.

A2.4.3 Using the adapted general symbolic form, draw reasonable conclusions about the situation being modeled.

STANDARD A3: FAMILIES OF FUNCTIONS

A3.1 Lines and Linear Functions

A3.1.1 Write the symbolic forms of linear functions (standard, point-slope, and slope-intercept) given appropriate information, and convert between forms.

A3.1.2 Graph lines (including those of the form $x = h$ and $y = k$) given appropriate information.

A3.1.3 Relate the coefficients in a linear function to the slope and x- and y-intercepts of its graph.

A3.1.4 Find an equation of the line parallel or perpendicular to given line, through a given point; understand and use the facts that non-vertical parallel lines have equal slopes, and that non-vertical perpendicular lines have slopes that multiply to give -1.

A3.2 Exponential and Logarithmic Functions

A3.2.1 Write the symbolic form and sketch the graph of an exponential function given appropriate information.

A3.2.2 Interpret the symbolic forms and recognize the graphs of exponential and logarithmic functions; recognize the logarithmic function as the inverse of the exponential function.

A3.2.3 Apply properties of exponential and logarithmic functions.

A3.2.4 Understand and use the fact that the base of an exponential function determines whether the function increases or decreases and understand how the base affects the rate of growth or decay.

A3.2.5 Relate exponential and logarithmic functions to real phenomena, including half-life and doubling time.

A3.3 Quadratic Functions

A3.3.1 Write the symbolic form and sketch the graph of a quadratic function given appropriate information.

A3.3.2 Identify the elements of a parabola (vertex, axis of symmetry, direction of opening) given its symbolic form or its graph, and relate these elements to the coefficient(s) of the symbolic form of the function.

A3.3.3 Convert quadratic functions from standard to vertex form by completing the square.

A3.3.4 Relate the number of real solutions of a quadratic equation to the graph of the associated quadratic function.

A3.3.5 Express quadratic functions in vertex form to identify their maxima or minima, and in factored form to identify their zeros.

A3.4 Power Functions

A3.4.1 Write the symbolic form and sketch the graph of power functions.

A3.4.2 Express direct and inverse relationships as functions and recognize their characteristics.

A3.4.3 Analyze the graphs of power functions, noting reflectional or rotational symmetry.

A3.5 Polynomial Functions

A3.5.1 Write the symbolic form and sketch the graph of simple polynomial functions.

A3.5.2 Understand the effects of degree, leading coefficient, and number of real zeros on the graphs of polynomial functions of degree greater than 2.

A3.5.3 Determine the maximum possible number of zeros of a polynomial function, and understand the relationship between the x-intercepts of the graph and the factored form of the function.

A3.6 Rational Functions

A3.6.1 Write the symbolic form and sketch the graph of simple rational functions.

A3.6.2 Analyze graphs of simple rational functions and understand the relationship between the zeros of the numerator and denominator and the function's intercepts, asymptotes, and domain.

A3.7 Trigonometric Functions

A3.7.1 Use the unit circle to define sine and cosine; approximate values of sine and cosine; use sine and cosine to define the remaining trigonometric functions; explain why the trigonometric functions are periodic.

A3.7.2 Use the relationship between degree and radian measures to solve problems.

A3.7.3 Use the unit circle to determine the exact values of sine and cosine, for integer multiples of $\frac{\pi}{6}$ and $\frac{\pi}{4}$.

A3.7.4 Graph the sine and cosine functions; analyze graphs by noting domain, range, period, amplitude, and location of maxima and minima.

A3.7.5 Graph transformations of basic trigonometric functions (involving changes in period, amplitude, and midline) and understand the relationship between constants in the formula and the transformed graph.

RECOMMENDED

A1.1.7 Transform trigonometric expressions into equivalent forms using basic identities such as $sin^2\theta + cos^2\theta = 1$ and $tan^2\theta + 1 = sec^2\theta$.

A2.2.4 If a function has an inverse, find the expression(s) for the inverse.

A2.2.5 Write an expression for the composition of one function with another; recognize component functions when a function is a composition of other functions.

A2.2.6 Know and interpret the function notation for inverses and verify that two functions are inverses using composition.

A2.4.4 Use methods of linear programming to represent and solve simple real-life problems.

STRAND 3: GEOMETRY AND TRIGONOMETRY

STANDARD G1: FIGURES AND THEIR PROPERTIES

G1.1 Lines and Angles; Basic Euclidean and Coordinate Geometry

G1.1.1 Solve multistep problems and construct proofs involving vertical angles, linear pairs of vhangles supplementary angles, complementary angles, and right angles.

G1.1.2 Solve multistep problems and construct proofs involving corresponding angles, alternate interior angles, alternate exterior angles, and same-side (consecutive) interior angles.

G1.1.3 Perform and justify constructions, including midpoint of a line segment and bisector of an angle, using straightedge and compass.

G1.1.4 Given a line and a point, construct a line through the point that is parallel to the original line using straightedge and compass. Given a line and a point, construct a line through the point that is perpendicular to the original line. Justify the steps of the constructions.

G1.1.5 Given a line segment in terms of its endpoints in the coordinate plane, determine its length and midpoint.

G1.1.6 Recognize Euclidean geometry as an axiom system. Know the key axioms and understand the meaning of and distinguish between undefined terms, axioms, definitions, and theorems.

G1.2 Triangles and Their Properties

G1.2.1 Prove that the angle sum of a triangle is 180° and that an exterior angle of a triangle is the sum of the two remote interior angles.

G1.2.2 Construct and justify arguments and solve multistep problems involving angle measure, side length, perimeter, and area of all types of triangles.

G1.2.3 Know a proof of the Pythagorean Theorem, and use the Pythagorean Theorem and its converse to solve multistep problems.

G1.2.4 Prove and use the relationships among the side lengths and the angles of 30°-60°-90° triangles and 45°-45°-90° triangles.

G1.2.5 Solve multistep problems and construct proofs about the properties of medians, altitudes, perpendicular bisectors to the sides of a triangle, and the angle bisectors of a triangle. Using a straightedge and compass, construct these lines.

G1.3 Triangles and Trigonometry

G1.3.1 Define the sine, cosine, and tangent of acute angles in a right triangle as ratios of sides. Solve problems about angles, side lengths, or areas using trigonometric ratios in right triangles.

G1.3.2 Know and use the Law of Sines and the Law of Cosines and use them to solve problems. Find the area of a triangle with sides a and b and included angle θ using the formula Area = $\left(\frac{1}{2}\right) ab \sin\theta$.

G1.3.3 Determine the exact values of sine, cosine, and tangent for 0°, 30°, 45°, 60°, and their integer multiples and apply in various contexts.

G1.4 Quadrilaterals and Their Properties

G1.4.1 Solve multistep problems and construct proofs involving angle measure, side length, diagonal length, perimeter, and area of squares, rectangles, parallelograms, kites, and trapezoids.

G1.4.2 Solve multistep problems and construct proofs involving quadrilaterals using Euclidean methods or coordinate geometry.

G1.4.3 Describe and justify hierarchical relationships among quadrilaterals.

G1.4.4 Prove theorems about the interior and exterior angle sums of a quadrilateral.

G1.5 Other Polygons and Their Properties

G1.5.1 Know and use subdivision or circumscription methods to find areas of polygons.

G1.5.2 Know, justify, and use formulas for the perimeter and area of a regular n-gon and formulas to find interior and exterior angles of a regular n-gon and their sums.

G1.6 Circles and Their Properties

G1.6.1 Solve multistep problems involving circumference and area of circles.

G1.6.2 Solve problems and justify arguments about chords and lines tangent to circles.

G1.6.3 Solve problems and justify arguments about central angles, inscribed angles, and triangles in circles.

G1.6.4 Know and use properties of arcs and sectors and find lengths of arcs and areas of sectors.

G1.7 Conic Sections and Their Properties

G1.7.1 Find an equation of a circle given its center and radius; given the equation of a circle, find its center and radius.

G1.7.2 Identify and distinguish among geometric representations of parabolas, circles, ellipses, and hyperbolas; describe their symmetries, and explain how they are related to cones.

G1.7.3 Graph ellipses and hyperbolas with axes parallel to the *x*- and *y*-axes, given equations.

G1.8 Three-Dimensional Figures

G1.8.1 Solve multistep problems involving surface area and volume of pyramids, prisms, cones, cylinders, hemispheres, and spheres.

G1.8.2 Identify symmetries of pyramids, prisms, cones, cylinders, hemispheres, and spheres.

STANDARD G2: RELATIONSHIPS BETWEEN FIGURES

G2.1 Relationships Between Area and Volume Formulas

G2.1.1 Know and demonstrate the relationships between the area formula of a triangle, the area formula of a parallelogram, and the area formula of a trapezoid.

G2.1.2 Know and demonstrate the relationships between the area formulas of various quadrilaterals.

G2.1.3 Know and use the relationship between the volumes of pyramids and prisms (of equal base and height) and cones and cylinders (of equal base and height).

G2.2 Relationships Between Two-dimensional and Three-dimensional Representations

G2.2.1 Identify or sketch a possible three-dimensional figure, given two-dimensional views. Create a two-dimensional representation of a three-dimensional figure.

G2.2.2 Identify or sketch cross sections of three-dimensional figures. Identify or sketch solids formed by revolving two-dimensional figures around lines.

G2.3 Congruence and Similarity

G2.3.1 Prove that triangles are congruent using the SSS, SAS, ASA, and AAS criteria, and that right triangles, are congruent using the hypotenuse-leg criterion.

G2.3.2 Use theorems about congruent triangles to prove additional theorems and solve problems, with and without use of coordinates.

G2.3.3 Prove that triangles are similar by using SSS, SAS, and AA conditions for similarity.

G2.3.4 Use theorems about similar triangles to solve problems with and without use of coordinates.

G2.3.5 Know and apply the theorem stating that the effect of a scale factor of *k* relating one two-dimensional figure to another or one three-dimensional figure to another, on the length, area, and volume of the figures is to multiply each by k, k^2, and k^3, respectively.

STANDARD G3: TRANSFORMATIONS OF FIGURES IN THE PLANE

G3.1 Distance-preserving Transformations: Isometries

G3.1.1 Define reflection, rotation, translation, and glide reflection and find the image of a figure under a given isometry.

G3.1.2 Given two figures that are images of each other under an isometry, find the isometry and describe it completely.

G3.1.3 Find the image of a figure under the composition of two or more isometries and determine whether the resulting figure is a reflection, rotation, translation, or glide reflection image of the original figure.

G3.2 Shape-preserving Transformations: Dilations and Isometries

G3.2.1 Know the definition of dilation and find the image of a figure under a given dilation.

G3.2.2 Given two figures that are images of each other under some dilation, identify the center and magnitude of the dilation

RECOMMENDED

G1.4.5 Understand the definition of a cyclic quadrillateral and know and use the basic properties of cyclic quadrilaterals.

G1.7.4 Know and use the relationship between the vertices and foci in and ellipse, the vertices and foci in a hyperboia, and the directrix and focus in a parabola, interpret these relationships in applied contexts.

G3.2.3 Find the image of a figure under the composition of a dilation and an isometry.

STRAND 4: STATISTICS AND PROBABILITY

STANDARD S1: UNIVARIATE DATA – EXAMINING DISTRIBUTIONS

S1.1 Producing and Interpreting Plots

S1.1.1 Construct and interpret dot plots, histograms, relative frequency histograms, bar graphs, basic control charts, and box plots with appropriate labels and scales; determine which kinds of plots are appropriate for different types of data; compare data sets and interpret differences based on graphs and summary statistics.

S1.1.2 Given a distribution of a variable in a data set, describe its shape, including symmetry or skewness, and state how the shape is related to measures of center (mean and median) and measures of variation (range and standard deviation) with particular attention to the effects of outliers on these measures.

S1.2 Measures of Center and Variation

S1.2.1 Calculate and interpret measures of center including: mean, median, and mode; explain uses, advantages and disadvantages of each measure given a particular set of data and its context.

S1.2.2 Estimate the position of the mean, median, and mode in both symmetrical and skewed distributions, and from a frequency distribution or histogram.

S1.2.3 Compute and interpret measures of variation, including percentiles, quartiles, interquartile range, variance, and standard deviation.

S1.3 The Normal Distribution

S1.3.1 Explain the concept of distribution and the relationship between summary statistics for a data set and parameters of a distribution.

S1.3.2 Describe characteristics of the normal distribution, including its shape and the relationships among its mean, median, and mode.

S1.3.3 Know and use the fact that about 68%, 95%, and 99.7% of the data lie within one, two, and three standard deviations of the mean, respectively in a normal distribution.

S1.3.4 Calculate *z*-scores, use *z*-scores to recognize outliers, and use *z*-scores to make informed decisions.

STANDARD S2: BIVARIATE DATA – EXAMINING RELATIONSHIPS

S2.1 Scatterplots and Correlation

S2.1.1 Construct a scatterplot for a bivariate data set with appropriate labels and scales.

S2.1.2 Given a scatterplot, identify patterns, clusters, and outliers. Recognize no correlation, weak correlation, and strong correlation.

S2.1.3 Estimate and interpret Pearson's correlation coefficient for a scatterplot of a bivariate data set. Recognize that correlation measures the strength of linear association.

S2.1.4 Differentiate between correlation and causation. Know that a strong correlation does not imply a cause-and-effect relationship. Recognize the role of lurking variables in correlation.

S2.2 Linear Regression

S2.2.1 For bivariate data that appear to form a linear pattern, find the least squares regression line by estimating visually and by calculating the equation of the regression line. Interpret the slope of the equation for a regression line.

S2.2.2 Use the equation of the least squares regression line to make appropriate predictions.

STANDARD S3: SAMPLES, SURVEYS, AND EXPERIMENTS

S3.1 Data Collection and Analysis

S3.1.1 Know the meanings of a sample from a population and a census of a population, and distinguish between sample statistics and population parameters.

S3.1.2 Identify possible sources of bias in data collection and sampling methods and simple experiments; describe how such bias can be reduced and controlled by random sampling; explain the impact of such bias on conclusions made from analysis of the data; and know the effect of replication on the precision of estimates.

S3.1.3 Distinguish between an observational study and an experimental study, and identify, in context, the conclusions that can be drawn from each.

STANDARD S4: PROBABILITY MODELS AND PROBABILITY CALCULATION

S4.1 Probability

S4.1.1 Understand and construct sample spaces in simple situations.

S4.1.2 Define mutually exclusive events, independent events, dependent events, compound events, complementary events and conditional probabilities; and use the definitions to compute probabilities.

S4.2 Application and Representation

S4.2.1 Compute probabilities of events using tree diagrams, formulas for combinations and permutations, Venn diagrams, or other counting techniques.

S4.2.2 Apply probability concepts to practical situations, in such settings as finance, health, ecology, or epidemiology, to make informed decisions.

RECOMMENDED

S3.1.4 Design simple experiments or investigations to collect data to answer questions of interest; interpret and present results.

S3.1.5 Understand methods of sampling, including random sampling, stratified sampling, and convenience samples, and be able to determine, in context, the advantages and disadvantages of each.

S3.1.6 Explain the importance of randomization, double-blind protocols, replication, and the placebo effect in designing experiments and interpreting the results of studies.

S3.2.1 Explain the basic ideas of statistical process control, including recording data from a process over time.

S3.2.2 Read and interpret basic control charts; detect patterns and departures from patterns.

S4.1.3 Design and carry out an appropriate simulation using random digits to estimate answers to questions about probability; estimate probabilities using results of a simulation; compare results of simulations to theoretical probabilities.

Michigan High School Earth Science
Content Standards and Expectations

STANDARD E1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

E1.1 Scientific Inquiry

E1.1A Generate new questions that can be investigated in the laboratory or field.

E1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.

E1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).

E1.1D Identify patterns in data and relate them to theoretical models.

E1.1E Describe a reason for a given conclusion using evidence from an investigation.

E1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.

E1.1g Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.

E1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.

E1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.

E1.2 Scientific Reflection and Social Implications

E1.2A Critique whether or not specific questions can be answered through scientific investigations.

E1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.

E1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.

E1.2D Evaluate scientific explanations in a peer review process or discussion format.

E1.2E Evaluate the future career and occupational prospects of science fields.

E1.2f Critique solutions to problems, given criteria and scientific constraints.

E1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.

E1.2h Describe the distinctions between scientific theories, laws, hypotheses, and observations.

E1.2i Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.

E1.2j Apply science principles or scientific data to anticipate effects of technological design decisions.

E1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.

STANDARD E2: EARTH SYSTEMS

E2.1 Earth Systems Overview

E2.1A Explain why the Earth is essentially a closed system in terms of matter.

E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.

E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.

E2.2 Energy in Earth Systems

E2.2A Describe the Earth's principal sources of internal and external energy (e.g., radioactive decay, gravity, solar energy).

E2.2B Identify differences in the origin and use of renewable (e.g., solar, wind, water, biomass) and nonrenewable (e.g., fossil fuels, nuclear [U-235]) sources of energy.

E2.2C Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.

E2.2D Identify the main sources of energy to the climate system.

E2.2e Explain how energy changes form through Earth systems.

E2.2f Explain how elements exist in different compounds and states as they move from one reservoir to another.

E2.3 Biogeochemical Cycles

E2.3A Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans.

E2.3b Explain why small amounts of some chemical forms may be beneficial for life but are poisonous in large quantities (e.g., dead zone in the Gulf of Mexico, Lake Nyos in Africa, fluoride in drinking water).

E2.3c Explain how the nitrogen cycle is part of the Earth system.

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E2.3d Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g., improve soils for agriculture) or harm (e.g., act as a pollutant) society.

E2.4 Resources and Human Impacts on Earth Systems

E2.4A Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits.

E2.4B Explain how the impact of human activities on the environment (e.g., deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems.

E2.4c Explain ozone depletion in the stratosphere and methods to slow human activities to reduce ozone depletion.

E2.4d Describe the life cycle of a product, including the resources, production, packaging, transportation, disposal, and pollution.

STANDARD E3: THE SOLID EARTH

E3.p1 Landforms and Soils (prerequisite)

E3.p1A Explain the origin of Michigan landforms. Describe and identify surface features using maps and satellite images. (prerequisite)

E3.p1B Explain how physical and chemical weathering leads to erosion and the formation of soils and sediments. (prerequisite)

E3.p1C Describe how coastal features are formed by wave erosion and deposition. (prerequisite)

E3.p2 Rocks and Minerals (prerequisite)

E3.p2A Identify common rock-forming minerals (quartz, feldspar, biotite, calcite, hornblende). (prerequisite)

E3.p2B Identify common igneous (granite, basalt, andesite, obsidian, pumice), metamorphic (schist, gneiss, marble, slate, quartzite), and sedimentary (sandstone, limestone, shale, conglomerate) rocks and describe the processes that change one kind of rock to another. (prerequisite)

E3.p3 Basic Plate Tectonics (prerequisite)

E3.p3A Describe geologic, paleontologic, and paleoclimatalogic evidence that indicates Africa and South America were once part of a single continent.

E3.p3B Describe the three types of plate boundaries (divergent, convergent, and transform) and geographic features associated with them (e.g., continental rifts and mid-ocean ridges, volcanic and island arcs, deep-sea trenches, transform faults).

E3.p3C Describe the three major types of volcanoes (shield volcano, stratovolcano, and cinder cones) and their relationship to the Ring of Fire.

E3.1 Advanced Rock Cycle

E3.1A Discriminate between igneous, metamorphic, and sedimentary rocks and describe the processes that change one kind of rock into another.

E3.1B Explain the relationship between the rock cycle and plate tectonics theory in regard to the origins of igneous, sedimentary, and metamorphic rocks.

E3.1c Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition.

E3.1d Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive.

E3.1e Explain how the texture (foliated, nonfoliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism.

E3.2 Interior of the Earth

E3.2A Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated.

E3.2B Explain how scientists infer that the Earth has interior layers with discernable properties using patterns of primary (*P*) and secondary (*S*) seismic wave arrivals.

E3.2C Describe the differences between oceanic and continental crust (including density, age, composition).

E3.2d Explain the uncertainties associated with models of the interior of the Earth and how these models are validated.

E3.3 Plate Tectonics Theory

E3.3A Explain how plate tectonics accounts for the features and processes (sea floor spreading, mid-ocean ridges, subduction zones, earthquakes and volcanoes, mountain ranges) that occur on or near the Earth's surface.

E3.3B Explain why tectonic plates move using the concept of heat flowing through mantle convection, coupled with the cooling and sinking of aging ocean plates that result from their increased density.

E3.3C Describe the motion history of geologic features (e.g., plates, Hawaii) using equations relating rate, time, and distance.

E3.3d Distinguish plate boundaries by the pattern of depth and magnitude of earthquakes.

E3.r3e Predict the temperature distribution in the lithosphere as a function of distance from the mid-ocean ridge and how it relates to ocean depth. (recommended)

E3.r3f Describe how the direction and rate of movement for the North American plate has affected the local climate over the last 600 million years. (recommended)

E3.4 Earthquakes and Volcanoes

E3.4A Use the distribution of earthquakes and volcanoes to locate and determine the types of plate boundaries.

E3.4B Describe how the sizes of earthquakes and volcanoes are measured or characterized.

E3.4C Describe the effects of earthquakes and volcanic eruptions on humans.

E3.4d Explain how the chemical composition of magmas relates to plate tectonics and affects the geometry, structure, and explosivity of volcanoes.

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E3.4e Explain how volcanoes change the atmosphere, hydrosphere, and other Earth systems.

E3.4f Explain why fences are offset after an earthquake, using the elastic rebound theory.

STANDARD E4: THE FLUID EARTH

E4.p1 Water Cycle (prerequisite)

E4.p1A Describe that the water cycle includes evaporation, transpiration, condensation, precipitation, infiltration, surface runoff, groundwater, and absorption. (prerequisite)

E4.p1B Analyze the flow of water between the elements of a watershed, including surface features (lakes, streams, rivers, wetlands) and groundwater. (prerequisite)

E4.p1C Describe the river and stream types, features, and process including cycles of flooding, erosion, and deposition as they occur naturally and as they are impacted by land use decisions. (prerequisite)

E4.p1D Explain the types, process, and beneficial functions of wetlands.

E4.p2 Weather and the Atmosphere (prerequisite)

E4.p2A Describe the composition and layers of the atmosphere. (prerequisite)

E4.p2B Describe the difference between weather and climate. (prerequisite)

E4.p2C Explain the differences between fog and dew formation and cloud formation. (prerequisite)

E4.p2D Describe relative humidity in terms of the moisture content of the air and the moisture capacity of the air and how these depend on the temperature. (prerequisite)

E4.p2E Describe conditions associated with frontal boundaries (cold, warm, stationary, and occluded). (prerequisite)

E4.p2F Describe the characteristics and movement across North America of the major air masses and the jet stream. (prerequisite)

E4.p2G Interpret a weather map and describe present weather conditions and predict changes in weather over 24 hours. (prerequisite)

E4.p2H Explain the primary causes of seasons. (prerequisite)

E4.p2I Identify major global wind belts (trade winds, prevailing westerlies, and polar easterlies) and that their vertical components control the global distribution of rainforests and deserts. (prerequisite)

E4.p3 Glaciers

E4.p3A Describe how glaciers have affected the Michigan landscape and how the resulting landforms impact our state economy. (prerequisite)

E4.p3B Explain what happens to the lithosphere when an ice sheet is removed. (prerequisite)

E4.p3C Explain the formation of the Great Lakes. (prerequisite)

E4.1 Hydrogeology

E4.1A Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).

E4.1B Explain the features and processes of groundwater systems and how the sustainability of North American aquifers has changed in recent history (e.g., the past 100 years) qualitatively using the concepts of recharge, residence time, inputs, and outputs.

E4.1C Explain how water quality in both groundwater and surface systems is impacted by land use decisions.

E4.2 Oceans and Climate

E4.2A Describe the major causes for the ocean's surface and deep water currents, including the prevailing winds, the Coriolis effect, unequal heating of the earth, changes in water temperature and salinity in high latitudes, and basin shape.

E4.2B Explain how interactions between the oceans and the atmosphere influence global and regional climate. Include the major concepts of heat transfer by ocean currents, thermohaline circulation, boundary currents, evaporation, precipitation, climatic zones, and the ocean as a major CO_2 reservoir.

E4.2c Explain the dynamics (including ocean-atmosphere interactions) of the El Niño-Southern Oscillation (ENSO) and its effect on continental climates.

E4.2d Identify factors affecting seawater density and salinity and describe how density affects oceanic layering and currents.

E4.2e Explain the differences between maritime and continental climates with regard to oceanic currents.

E4.2f Explain how the Coriolis effect controls oceanic circulation.

E4.r2g Explain how El Niño affects economies (e.g., in South America). (recommended)

E4.3 Severe Weather

E4.3A Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).

E4.3B Describe the damage resulting from, and the social impact of thunderstorms, tornadoes, hurricanes, and floods.

E4.3C Describe severe weather and flood safety and mitigation.

E4.3D Describe the seasonal variations in severe weather.

E4.3E Describe conditions associated with frontal boundaries that result in severe weather (thunderstorms, tornadoes, and hurricanes).

E4.3F Describe how mountains, frontal wedging (including dry lines), convection, and convergence form clouds and precipitation.

E4.3g Explain the process of adiabatic cooling and adiabatic temperature changes to the formation of clouds.

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STANDARD E5: THE EARTH IN SPACE AND TIME

E5.p1 Sky Observations (prerequisite)

E5.p1A Describe the motions of various celestial bodies and some effects of those motions. (prerequisite)

E5.p1B Explain the primary cause of seasons. (prerequisite)

E5.p1C Explain how a light year can be used as a distance unit. (prerequisite)

E5.p1D Describe the position and motion of our solar system in our galaxy. (prerequisite)

E5.1 The Earth in Space

E5.1A Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe.

E5.1b Describe how the Big Bang theory accounts for the formation of the universe.

E5.1c Explain how observations of the cosmic microwave background have helped determine the age of the universe.

E5.1d Differentiate between the cosmological and Doppler red shift.

E5.2 The Sun

E5.2A Identify patterns in solar activities (sunspot cycle, solar flares, solar wind).

E5.2B Relate events on the Sun to phenomena such as auroras, disruption of radio and satellite communications, and power grid disturbances.

E5.2C Describe how nuclear fusion produces energy in the Sun.

E5.2D Describe how nuclear fusion and other processes in stars have led to the formation of all the other chemical elements.

E5.2x Stellar Evolution

E5.2e Explain how the Hertzsprung-Russell (H-R) diagram can be used to deduce other parameters (distance).

E5.2f Explain how you can infer the temperature, life span, and mass of a star from its color. Use the H-R diagram to explain the life cycles of stars.

E5.2g Explain how the balance between fusion and gravity controls the evolution of a star (equilibrium).

E5.2h Compare the evolution paths of low-, moderate-, and high-mass stars using the H-R diagram.

E5.3 Earth History and Geologic Time

E5.3A Explain how the solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 Ga (billion years ago).

E5.3B Describe the process of radioactive decay and explain how radioactive elements are used to date the rocks that contain them.

E5.3C Relate major events in the history of the Earth to the geologic time scale, including formation of the Earth, formation of an oxygen atmosphere, rise of life, Cretaceous-Tertiary (K-T) and Permian extinctions, and Pleistocene ice age.

E5.3D Describe how index fossils can be used to determine time sequence.

E5.3x Geologic Dating

E5.3e Determine the approximate age of a sample, when given the half-life of a radioactive substance (in graph or tabular form) along with the ratio of daughter to parent substances present in the sample.

E5.3f Explain why C-14 can be used to date a 40,000 year old tree, but U-Pb cannot.

E5.3g Identify a sequence of geologic events using relative-age dating principles.

E5.4 Climate Change

E5.4A Explain the natural mechanism of the greenhouse effect, including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone).

E5.4B Describe natural mechanisms that could result in significant changes in climate (e.g., major volcanic eruptions, changes in sunlight received by the earth, and meteorite impacts).

E5.4C Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years.

E5.4D Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity of the biosphere).

E5.4e Based on evidence from historical climate research (e.g. fossils, varves, ice core data) and climate change models, explain how the current melting of polar ice caps can impact the climatic system.

E5.4f Describe geologic evidence that implies climates were significantly colder at times in the geologic record (e.g., geomorphology, striations, and fossils).

E5.4g Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat-trapping capacity.

E5.r4h Use oxygen isotope data to estimate paleotemperature. (recommended)

E5.r4i Explain the causes of short-term climate changes such as catastrophic volcanic eruptions and impact of solar system objects. (recommended)

E5.r4j Predict the global temperature increase by 2100, given data on the annual trends of CO2 concentration increase (recommended)

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STANDARD B1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

B1.1 Scientific Inquiry

B1.1A Generate new questions that can be investigated in the laboratory or field.

B1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.

B1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).

B1.1D Identify patterns in data and relate them to theoretical models.

B1.1E Describe a reason for a given conclusion using evidence from an investigation.

B1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.

B1.1g Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.

B1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.

B1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.

B1.2 Scientific Reflection and Social Implications

B1.2A Critique whether or not specific questions can be answered through scientific investigations.

B1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.

B1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.

B1.2D Evaluate scientific explanations in a peer review process or discussion format.

B1.2E Evaluate the future career and occupational prospects of science fields.

B1.2f Critique solutions to problems, given criteria and scientific constraints.

B1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.

B1.2h Describe the distinctions between scientific theories, laws, hypotheses, and observations.

B1.2i Explain the progression of ideas and explanations that leads to science theories that are part of the current scientific consensus or core knowledge.

B1.2j Apply science principles or scientific data to anticipate effects of technological design decisions.

B1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.

STANDARD B2: ORGANIZATION AND DEVELOPMENT OF LIVING SYSTEMS

L2.p1 Cells (prerequisite)

L2.p1A Distinguish between living and nonliving systems. (prerequisite)

L2.p1B Explain the importance of both water and the element carbon to cells. (prerequisite)

L2.p1C Describe growth and development in terms of increase in cell number, cell size, and/or cell products. (prerequisite)

L2.p1D Explain how the systems in a multicellular organism work together to support the organism. (prerequisite)

L2.p1E Compare and contrast how different organisms accomplish similar functions (e.g., obtain oxygen for respiration, and excrete waste). (prerequisite)

L2.p2 Cell Function (prerequisite)

L2.p2A Describe how organisms sustain life by obtaining, transporting, transforming, releasing, and eliminating matter and energy. (prerequisite)

L2.p2B Describe the effect of limiting food to developing cells. (prerequisite)

L2.p3 Plants as Producers (prerequisite)

L2.p3A Explain the significance of carbon in organic molecules. (prerequisite)

L2.p3B Explain the origins of plant mass. (prerequisite)

L2.p3C Predict what would happen to plants growing in low carbon dioxide atmospheres. (prerequisite)

L2.p3D Explain how the roots of specific plants grow. (prerequisite)

L2.p4 Animals as Consumers (prerequisite)

L2.p4A Classify different organisms based on how they obtain energy for growth and development. (prerequisite)

L2.p4B Explain how an organism obtains energy from the food it consumes. (prerequisite)

L2.p5 Common Elements (prerequisite)

L2.p5A Recognize the six most common elements in organic molecules (C, H, N, O, P, S). (prerequisite)

L2.p5B Identify the most common complex molecules that make up living organisms. (prerequisite)

L2.p5C Predict what would happen if essential elements were withheld from developing cells. (prerequisite)

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B2.1 Transformation of Matter and Energy in Cells

B2.1A Explain how cells transform energy (ultimately obtained from the sun) from one form to another through the processes of photosynthesis and respiration. Identify the reactants and products in the general reaction of photosynthesis.

B2.1B Compare and contrast the transformation of matter and energy during photosynthesis and respiration.

B2.1C Explain cell division, growth, and development as a consequence of an increase in cell number, cell size, and/or cell products.

B2.1x Cell Differentiation

B2.1d Describe how, through cell division, cells can become specialized for specific function.

B2.1e Predict what would happen if the cells from one part of a developing embryo were transplanted to another part of the embryo.

B2.2 Organic Molecules

B2.2A Explain how carbon can join to other carbon atoms in chains and rings to form large and complex molecules.

B2.2B Recognize the six most common elements in organic molecules (C, H, N, O, P, S).

B2.2C Describe the composition of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).

B2.2D Explain the general structure and primary functions of the major complex organic molecules that compose living organisms.

B2.2E Describe how dehydration and hydrolysis relate to organic molecules.

B2.2x Proteins

B2.2f Explain the role of enzymes and other proteins in biochemical functions (e.g., the protein hemoglobin carries oxygen in some organisms, digestive enzymes, and hormones).

B2.2g Propose how moving an organism to a new environment may influence its ability to survive and predict the possible impact of this type of transfer.

B2.3 Maintaining Environmental Stability

B2.3A Describe how cells function in a narrow range of physical conditions, such as temperature and pH (acidity), to perform life functions.

B2.3B Describe how the maintenance of a relatively stable internal environment is required for the continuation of life.

B2.3C Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents.

B2.3x Homeostasis

B2.3d Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.

B2.3e Describe how human body systems maintain relatively constant internal conditions (temperature, acidity, and blood sugar).

B2.3f Explain how human organ systems help maintain human health.

B2.3g Compare the structure and function of a human body system or subsystem to a nonliving system (e.g., human joints to hinges, enzyme and substrate to interlocking puzzle pieces).

B2.4 Cell Specialization

B2.4A Explain that living things can be classified based on structural, embryological, and molecular (relatedness of DNA sequence) evidence.

B2.4B Describe how various organisms have developed different specializations to accomplish a particular function and yet the end result is the same (e.g., excreting nitrogenous wastes in animals, obtaining oxygen for respiration).

B2.4C Explain how different organisms accomplish the same result using different structural specializations (gills vs. lungs vs. membranes).

B2.4d Analyze the relationships among organisms based on their shared physical, biochemical, genetic, and cellular characteristics and functional processes.

B2.4e Explain how cellular respiration is important for the production of ATP (build on aerobic vs. anaerobic).

B2.4f Recognize and describe that both living and nonliving things are composed of compounds, which are themselves made up of elements joined by energy-containing bonds, such as those in ATP.

B2.4g Explain that some structures in the modern eukaryotic cell developed from early prokaryotes, such as mitochondria, and in plants, chloroplasts.

B2.4h Describe the structures of viruses and bacteria.

B2.4i Recognize that while viruses lack cellular structure, they have the genetic material to invade living cells.

B2.5 Living Organism Composition

B2.5A Recognize and explain that macromolecules such as lipids contain high energy bonds.

B2.5B Explain how major systems and processes work together in animals and plants, including relationships between organelles, cells, tissues, organs, organ systems, and organisms. Relate these to molecular functions.

B2.5C Describe how energy is transferred and transformed from the Sun to energy-rich molecules during photosynthesis.

B2.5D Describe how individual cells break down energy-rich molecules to provide energy for cell functions.

B2.5x Energy Transfer

B2.5e Explain the interrelated nature of photosynthesis and cellular respiration in terms of ATP synthesis and degradation.

B2.5f Relate plant structures and functions to the process of photosynthesis and respiration.

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B2.5g Compare and contrast plant and animal cells.

B2.5h Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, and active transport).

B2.5i Relate cell parts/organelles to their function.

B2.6x Internal/External Cell Regulation

B2.6a Explain that the regulatory and behavioral responses of an organism to external stimuli occur in order to maintain both short- and long-term equilibrium.

B2.r6b Explain that complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Note that cell behavior can also be affected by molecules from other parts of the organism, such as hormones. (recommended)

B2.r6c Recognize and explain that communication and/or interaction are required between cells to coordinate their diverse activities. (recommended)

B2.r6d Explain how higher levels of organization result from specific complex interactions of smaller units and that their maintenance requires a constant input of energy as well as new material. (recommended)

B2.r6e Analyze the body's response to medical interventions such as organ transplants, medicines, and inoculations. (recommended)

STANDARD B3: INTERDEPENDENCE OF LIVING SYSTEMS AND THE ENVIRONMENT

L3.p1 Populations, Communities, and Ecosystems (prerequisite)

L3.p1A Provide examples of a population, community, and ecosystem. (prerequisite)

L3.p2 Relationships Among Organisms (prerequisite)

L3.p2A Describe common relationships among organisms and provide examples of producer/consumer, predator/prey, or parasite/host relationship. (prerequisite)

L3.p2B Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors). (prerequisite)

L3.p2C Describe the role of decomposers in the transfer of energy in an ecosystem. (prerequisite)

L3.p2D Explain how two organisms can be mutually beneficial and how that can lead to interdependency. (prerequisite)

L3.p3 Factors Influencing Ecosystems (prerequisite)

L3.p3A Identify the factors in an ecosystem that influence fluctuations in population size. (prerequisite)

L3.p3B Distinguish between the living (biotic) and nonliving (abiotic) components of an ecosystem. (prerequisite)

L3.p3C Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen). (prerequisite)

L3.p3D Predict how changes in one population might affect other populations based upon their relationships in a food web. (prerequisite)

L3.p4 Human Impact on Ecosystems (prerequisite)

L3.p4A Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. (prerequisite)

B3.1 Photosynthesis and Respiration

B3.1A Describe how organisms acquire energy directly or indirectly from sunlight.

B3.1B Illustrate and describe the energy conversions that occur during photosynthesis and respiration.

B3.1C Recognize the equations for photosynthesis and respiration and identify the reactants and products for both.

B3.1D Explain how living organisms gain and use mass through the processes of photosynthesis and respiration.

B3.1e Write the chemical equation for photosynthesis and cellular respiration and explain in words what they mean.

B3.1f Summarize the process of photosynthesis.

B3.2 Ecosystems

B3.2A Identify how energy is stored in an ecosystem.

B3.2B Describe energy transfer through an ecosystem, accounting for energy lost to the environment as heat.

B3.2C Draw the flow of energy through an ecosystem. Predict changes in the food web when one or more organisms are removed.

B3.3 Element Recombination

B3.3A Use a food web to identify and distinguish producers, consumers, and decomposers and explain the transfer of energy through trophic levels.

B3.3b Describe environmental processes (e.g., the carbon and nitrogen cycles) and their role in processing matter crucial for sustaining life.

B3.4 Changes in Ecosystems

B3.4A Describe ecosystem stability. Understand that if a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages of succession that eventually result in a system similar to the original one.

B3.4B Recognize and describe that a great diversity of species increases the chance that at least some living organisms will survive in the face of cataclysmic changes in the environment.

B3.4C Examine the negative impact of human activities.

B3.4x Human Impact

B3.4d Describe the greenhouse effect and list possible causes.

B3.4e List the possible causes and consequences of global warming.

B3.5 Populations

B3.5A Graph changes in population growth, given a data table.

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B3.5B Explain the influences that affect population growth.

B3.5C Predict the consequences of an invading organism on the survival of other organisms.

B3.5x Environmental Factors

B3.5d Describe different reproductive strategies employed by various organisms and explain their advantages and disadvantages.

B3.5e Recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of population dynamics within ecosystems.

B3.5f Graph an example of exponential growth. Then show the population leveling off at the carrying capacity of the environment.

B3.r5g Diagram and describe the stages of the life cycle for a human disease-causing organism. (recommended)

STANDARD B4: GENETICS

L4.p1 Reproduction (prerequisite)

L4.p1A Compare and contrast the differences between sexual and asexual reproduction. (prerequisite)

L4.p1B Discuss the advantages and disadvantages of sexual vs. asexual reproduction. (prerequisite)

L4.p2 Heredity and Environment (prerequisite)

L4.p2A Explain that the traits of an individual are influenced by both the environment and the genetics of the individual. Acquired traits are not inherited; only genetic traits are inherited. (prerequisite)

B4.1 Genetics and Inherited Traits

B4.1A Draw and label a homologous chromosome pair with heterozygous alleles highlighting a particular gene location.

B4.1B Explain that the information passed from parents to offspring is transmitted by means of genes that are coded in DNA molecules. These genes contain the information for the production of proteins.

B4.1c Differentiate between dominant, recessive, codominant, polygenic, and sex-linked traits.

B4.1d Explain the genetic basis for Mendel's laws of segregation and independent assortment.

B4.1e Determine the genotype and phenotype of monohybrid crosses using a Punnett Square.

B4.2A Show that when mutations occur in sex cells, they can be passed on to offspring (inherited mutations), but if they occur in other cells, they can be passed on to descendant cells only (noninherited mutations).

B4.2B Recognize that every species has its own characteristic DNA sequence.

B4.2C Describe the structure and function of DNA.

B4.2D Predict the consequences that changes in the DNA composition of particular genes may have on an organism (e.g., sickle cell anemia, other).

B4.2E Propose possible effects (on the genes) of exposing an organism to radiation and toxic chemicals.

B4.2x DNA, RNA, and Protein Synthesis

B4.2f Demonstrate how the genetic information in DNA molecules provides instructions for assembling protein molecules and that this is virtually the same mechanism for all life forms.

B4.2g Describe the processes of replication, transcription, and translation and how they relate to each other in molecular biology.

B4.2h Recognize that genetic engineering techniques provide great potential and responsibilities.

B4.r2i Explain how recombinant DNA technology allows scientists to analyze the structure and function of genes.

B4.3 Cell Division—Mitosis and Meiosis

B4.3A Compare and contrast the processes of cell division (mitosis and meiosis), particularly as those processes relate to production of new cells and to passing on genetic information between generations.

B4.3B Explain why only mutations occurring in gametes (sex cells) can be passed on to offspring.

B4.3C Explain how it might be possible to identify genetic defects from just a karyotype of a few cells.

B4.3d Explain that the sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations from the offspring of two parents.

B4.3e Recognize that genetic variation can occur from such processes as crossing over, jumping genes, and deletion and duplication of genes.

B4.3f Predict how mutations may be transferred to progeny.

B4.3g Explain that cellular differentiation results from gene expression and/or environmental influence (e.g., metamorphosis, nutrition).

B4.4x Genetic Variation

B4.4a Describe how inserting, deleting, or substituting DNA segments can alter a gene. Recognize that an altered gene may be passed on to every cell that develops from it and that the resulting features may help, harm, or have little or no effect on the offspring's success in its environment.

B4.4b Explain that gene mutation in a cell can result in uncontrolled cell division called cancer. Also know that exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.

B4.4c Explain how mutations in the DNA sequence of a gene may be silent or result in phenotypic change in an organism and in its offspring.

B4.r5x **Recombinant DNA**

B4.r5a Explain how recombinant DNA technology allows scientists to analyze the structure and function of genes. (recommended)

B4.r5b Evaluate the advantages and disadvantages of human manipulation of DNA. (recommended)

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STANDARD B5: EVOLUTION AND BIODIVERSITY

L5.p1 Survival and Extinction (prerequisite)

L5.p1A Define a species and give examples. (prerequisite)

L5.p1B Define a population and identify local populations. (prerequisite)

L5.p1C Explain how extinction removes genes from the gene pool. (prerequisite)

L5.p1D Explain the importance of the fossil record. (prerequisite)

L5.p2 Classification (prerequisite)

L5.p2A Explain, with examples, that ecology studies the varieties and interactions of living things across space while evolution studies the varieties and interactions of living things across time. (prerequisite)

B5.1 Theory of Evolution

B5.1A Summarize the major concepts of natural selection (differential survival and reproduction of chance inherited variants, depending on environmental conditions).

B5.1B Describe how natural selection provides a mechanism for evolution.

B5.1c Summarize the relationships between present-day organisms and those that inhabited the Earth in the past (e.g., use fossil record, embryonic stages, homologous structures, chemical basis).

B5.1d Explain how a new species or variety originates through the evolutionary process of natural selection.

B5.1e Explain how natural selection leads to organisms that are well suited for the environment (differential survival and reproduction of chance inherited variants, depending upon environmental conditions).

B5.1f Explain, using examples, how the fossil record, comparative anatomy, and other evidence supports the theory of evolution.

B5.1g Illustrate how genetic variation is preserved or eliminated from a population through natural selection (evolution) resulting in biodiversity.

B5.2x Molecular Evidence

B5.2a Describe species as reproductively distinct groups of organisms that can be classified based on morphological, behavioral, and molecular similarities.

B5.2b Explain that the degree of kinship between organisms or species can be estimated from the similarity of their DNA and protein sequences.

B5.2c Trace the relationship between environmental changes and changes in the gene pool, such as genetic drift and isolation of subpopulations.

B5.r2d Interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms. (recommended)

B5.3 Natural Selection

B5.3A Explain how natural selection acts on individuals, but it is populations that evolve. Relate genetic mutations and genetic variety produced by sexual reproduction to diversity within a given population.

B5.3B Describe the role of geographic isolation in speciation.

B4.3C Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.

B5.3d Explain how evolution through natural selection can result in changes in biodiversity.

B5.3e Explain how changes at the gene level are the foundation for changes in populations and eventually the formation of new species.

B5.3f Demonstrate and explain how biotechnology can improve a population and species

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STANDARD P1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

P1.1 Scientific Inquiry

P1.1A Generate new questions that can be investigated in the laboratory or field.

P1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.

P1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).

P1.1D Identify patterns in data and relate them to theoretical models.

P1.1E Describe a reason for a given conclusion using evidence from an investigation.

P1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.

P1.1g Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.

P1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.

P1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.

P1.2 Scientific Reflection and Social Implications

P1.2A Critique whether or not specific questions can be answered through scientific investigations.

P1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.

P1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.

P1.2D Evaluate scientific explanations in a peer review process or discussion format.

P1.2E Evaluate the future career and occupational prospects of science fields.

P1.2f Critique solutions to problems, given criteria and scientific constraints.

P1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.

P1.2h Describe the distinctions between scientific theories, laws, hypotheses, and observations.

P1.2i Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.

P1.2j Apply science principles or scientific data to anticipate effects of technological design decisions.

P1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.

STANDARD P2: MOTION OF OBJECTS

P2.1 Position—Time

P2.1A Calculate the average speed of an object using the change of position and elapsed time.

P2.1B Represent the velocities for linear and circular motion using motion diagrams (arrows on strobe pictures).

P2.1C Create line graphs using measured values of position and elapsed time.

P2.1D Describe and analyze the motion that a position-time graph represents, given the graph.

P2.1E Describe and classify various motions in a plane as one dimensional, two dimensional, circular, or periodic.

P2.1F Distinguish between rotation and revolution and describe and contrast the two speeds of an object like the Earth.

P2.1g Solve problems involving average speed and constant acceleration in one dimension.

P2.1h Identify the changes in speed and direction in everyday examples of circular (rotation and revolution), periodic, and projectile motions.

P2.2 Velocity—Time

P2.2A Distinguish between the variables of distance, displacement, speed, velocity, and acceleration.

P2.2B Use the change of speed and elapsed time to calculate the average acceleration for linear motion.

P2.2C Describe and analyze the motion that a velocity-time graph represents, given the graph.

P2.2D State that uniform circular motion involves acceleration without a change in speed.

P2.2e Use the area under a velocity-time graph to calculate the distance traveled and the slope to calculate the acceleration.

P2.2f Describe the relationship between changes in position, velocity, and acceleration during periodic motion.

P2.2g Apply the independence of the vertical and horizontal initial velocities to solve projectile motion problems.

P2.3x Frames of Reference

P2.3a Describe and compare the motion of an object using different reference frames.

STANDARD P3: FORCES AND MOTION

P3.1 Basic Forces in Nature

P3.1A Identify the force(s) acting between objects in "direct contact" or at a distance.

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P3.1x Forces

P3.1b Explain why scientists can ignore the gravitational force when measuring the net force between two electrons.

P3.1c Provide examples that illustrate the importance of the electric force in everyday life.

P3.1d Identify the basic forces in everyday interactions.

P3.2 Net Forces

P3.2A Identify the magnitude and direction of everyday forces (e.g., wind, tension in ropes, pushes and pulls, weight).

P3.2B Compare work done in different situations.

P3.2C Calculate the net force acting on an object.

P3.2d Calculate all the forces on an object on an inclined plane and describe the object's motion based on the forces using free-body diagrams.

P3.3 Newton's Third Law

P3.3A Identify the action and reaction force from examples of forces in everyday situations (e.g., book on a table, walking across the floor, pushing open a door).

P3.3b Predict how the change in velocity of a small mass compares to the change in velocity of a large mass when the objects interact (e.g., collide).

P3.3c Explain the recoil of a projectile launcher in terms of forces and masses.

P3.3d Analyze why seat belts may be more important in autos than in buses.

P3.4 Forces and Acceleration

P3.4A Predict the change in motion of an object acted on by several forces.

P3.4B Identify forces acting on objects moving with constant velocity (e.g., cars on a highway).

P3.4C Solve problems involving force, mass, and acceleration in linear motion (Newton's second law).

P3.4D Identify the force(s) acting on objects moving with uniform circular motion (e.g., a car on a circular track, satellites in orbit).

P3.4e Solve problems involving force, mass, and acceleration in two-dimensional projectile motion restricted to an initial horizontal velocity with no initial vertical velocity (e.g., ball rolling off a table).

P3.4f Calculate the changes in velocity of a thrown or hit object during and after the time it is acted on by the force.

P3.4g Explain how the time of impact can affect the net force (e.g., air bags in cars, catching a ball).

P3.5x Momentum

P3.5a Apply conservation of momentum to solve simple collision problems.

P3.6 Gravitational Interactions

P3.6A Explain earth-moon interactions (orbital motion) in terms of forces.

P3.6B Predict how the gravitational force between objects changes when the distance between them changes.

P3.6C Explain how your weight on Earth could be different from your weight on another planet.

P3.6d Calculate force, masses, or distance, given any three of these quantities, by applying the Law of Universal Gravitation, given the value of *G*.

P3.6e Draw arrows (vectors) to represent how the direction and magnitude of a force changes on an object in an elliptical orbit.

P3.7 Electric Charges

P3.7A Predict how the electric force between charged objects varies when the distance between them and/or the magnitude of charges change.

P3.7B Explain why acquiring a large excess static charge (e.g., pulling off a wool cap, touching a Van de Graaff generator, combing) affects your hair.

P3.7x Electric Charges—Interactions

P3.7c Draw the redistribution of electric charges on a neutral object when a charged object is brought near.

P3.7d Identify examples of induced static charges.

P3.7e Explain why an attractive force results from bringing a charged object near a neutral object.

P3.7f Determine the new electric force on charged objects after they touch and are then separated.

P3.7g Propose a mechanism based on electric forces to explain current flow in an electric circuit.

P3.p8 Magnetic Force (prerequisite)

P3.p8A Create a representation of magnetic field lines around a bar magnet and qualitatively describe how the relative strength and direction of the magnetic force changes at various places in the field. (prerequisite)

P3.8x Electromagnetic Force

P3.8b Explain how the interaction of electric and magnetic forces is the basis for electric motors, generators, and the production of electromagnetic waves.

STANDARD P4: FORMS OF ENERGY AND ENERGY TRANSFORMATIONS

P4.1 Energy Transfer

P4.1A Account for and represent energy into and out of systems using energy transfer diagrams.

P4.1B Explain instances of energy transfer by waves and objects in everyday activities (e.g., why the ground gets warm during the day, how you hear a distant sound, why it hurts when you are hit by a baseball).

P4.1x Energy Transfer—Work

P4.1c Explain why work has a more precise scientific meaning than the meaning of work in everyday language.

P4.1d Calculate the amount of work done on an object that is moved from one position to another.

P4.1e Using the formula for work, derive a formula for change in potential energy of an object lifted a distance *h*.

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P4.2 Energy Transformation

P4.2A Account for and represent energy transfer and transformation in complex processes (interactions).

P4.2B Name devices that transform specific types of energy into other types (e.g., a device that transforms electricity into motion).

P4.2C Explain how energy is conserved in common systems (e.g., light incident on a transparent material, light incident on a leaf, mechanical energy in a collision).

P4.2D Explain why all the stored energy in gasoline does not transform to mechanical energy of a vehicle.

P4.2e Explain the energy transformation as an object (e.g., skydiver) falls at a steady velocity.

P4.2F Identify and label the energy inputs, transformations, and outputs using qualitative or quantitative representations in simple technological systems (e.g., toaster, motor, hair dryer) to show energy conservation.

P4.3 Kinetic and Potential Energy

P4.3A Identify the form of energy in given situations (e.g., moving objects, stretched springs, rocks on cliffs, energy in food).

P4.3B Describe the transformation between potential and kinetic energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts).

P4.3C Explain why all mechanical systems require an external energy source to maintain their motion.

P4.3x Kinetic and Potential Energy—Calculations

P4.3d Rank the amount of kinetic energy from highest to lowest of everyday examples of moving objects.

P4.3e Calculate the changes in kinetic and potential energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts) using the formulas for kinetic energy and potential energy.

P4.3f Calculate the impact speed (ignoring air resistance) of an object dropped from a specific height or the maximum height reached by an object (ignoring air resistance), given the initial vertical velocity.

P4.4 Wave Characteristics

P4.4A Describe specific mechanical waves (e.g., on a demonstration spring, on the ocean) in terms of wavelength, amplitude, frequency, and speed.

P4.4B Identify everyday examples of transverse and compression (longitudinal) waves.

P4.4C Compare and contrast transverse and compression (longitudinal) waves in terms of wavelength, amplitude, and frequency.

P4.4x Wave Characteristics—Calculations

P4.4d Demonstrate that frequency and wavelength of a wave are inversely proportional in a given medium.

P4.4e Calculate the amount of energy transferred by transverse or compression waves of different amplitudes and frequencies (e.g., seismic waves).

P4.5 Mechanical Wave Propagation

P4.5A Identify everyday examples of energy transfer by waves and their sources.

P4.5B Explain why an object (e.g., fishing bobber) does not move forward as a wave passes under it.

P4.5C Provide evidence to support the claim that sound is energy transferred by a wave, not energy transferred by particles.

P4.5D Explain how waves propagate from vibrating sources and why the intensity decreases with the square of the distance from a point source.

P4.5E Explain why everyone in a classroom can hear one person speaking, but why an amplification system is often used in the rear of a large concert auditorium.

P4.6 Electromagnetic Waves

P4.6A Identify the different regions on the electromagnetic spectrum and compare them in terms of wavelength, frequency, and energy.

P4.6B Explain why radio waves can travel through space, but sound waves cannot.

P4.6C Explain why there is a delay between the time we send a radio message to astronauts on the moon and when they receive it.

P4.6D Explain why we see a distant event before we hear it (e.g., lightning before thunder, exploding fireworks before the boom).

P4.6x Electromagnetic Propagation

P4.6e Explain why antennas are needed for radio, television, and cell phone transmission and reception.

P4.6f Explain how radio waves are modified to send information in radio and television programs, radio-control cars, cell phone conversations, and GPS systems.

P4.6g Explain how different electromagnetic signals (e.g., radio station broadcasts or cell phone conversations) can take place without interfering with each other.

P4.6h Explain the relationship between the frequency of an electromagnetic wave and its technological uses.

P4.r7x Quantum Theory of Waves (recommended)

P4.r7a Calculate and compare the energy in various electromagnetic quanta (e.g., visible light, x-rays). (recommended)

P4.8 Wave Behavior—Reflection and Refraction

P4.8A Draw ray diagrams to indicate how light reflects off objects or refracts into transparent media.

P4.8B Predict the path of reflected light from flat, curved, or rough surfaces (e.g., flat and curved mirrors, painted walls, paper).

P4.8x Wave Behavior—Diffraction, Interference, and Refraction

P4.8c Describe how two wave pulses propagated from opposite ends of a demonstration spring interact as they meet.

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P4.8d List and analyze everyday examples that demonstrate the interference characteristics of waves (e.g., dead spots in an auditorium, whispering galleries, colors in a CD, beetle wings).

P4.8e Given an angle of incidence and indices of refraction of two materials, calculate the path of a light ray incident on the boundary (Snell's Law).

P4.8f Explain how Snell's Law is used to design lenses (e.g., eye glasses, microscopes, telescopes, binoculars).

P4.9 Nature of Light

P4.9A Identify the principle involved when you see a transparent object (e.g., straw, piece of glass) in a clear liquid.

P4.9B Explain how various materials reflect, absorb, or transmit light in different ways.

P4.9C Explain why the image of the Sun appears reddish at sunrise and sunset.

P4.r9x Nature of Light—Wave-Particle Nature (recommended)

P4.r9d Describe evidence that supports the dual wave - particle nature of light. (recommended)

P4.10 Current Electricity—Circuits

P4.10A Describe the energy transformations when electrical energy is produced and transferred to homes and businesses.

P4.10B Identify common household devices that transform electrical energy to other forms of energy, and describe the type of energy transformation.

P4.10C Given diagrams of many different possible connections of electric circuit elements, identify complete circuits, open circuits, and short circuits and explain the reasons for the classification.

P4.10D Discriminate between voltage, resistance, and current as they apply to an electric circuit.

P4.10x Current Electricity—Ohm's Law, Work, and Power

P4.10e Explain energy transfer in a circuit, using an electrical charge model.

P4.10f Calculate the amount of work done when a charge moves through a potential difference, *V*.

P4.10g Compare the currents, voltages, and power in parallel and series circuits.

P4.10h Explain how circuit breakers and fuses protect household appliances.

P4.10i Compare the energy used in one day by common household appliances (e.g., refrigerator, lamps, hair dryer, toaster, televisions, music players).

P4.10j Explain the difference between electric power and electric energy as used in bills from an electric company.

P4.11x Heat, Temperature, and Efficiency

P4.11a Calculate the energy lost to surroundings when water in a home water heater is heated from room temperature to the temperature necessary to use in a dishwasher, given the efficiency of the home hot water heater.

P4.11b Calculate the final temperature of two liquids (same or different materials) at the same or different temperatures and masses that are combined.

P4.12 Nuclear Reactions

P4.12A Describe peaceful technological applications of nuclear fission and radioactive decay.

P4.12B Describe possible problems caused by exposure to prolonged radioactive decay.

P4.12C Explain how stars, including our Sun, produce huge amounts of energy (e.g., visible, infrared, ultraviolet light).

P4.12x Mass and Energy

P4.12d Identify the source of energy in fission and fusion nuclear reactions.

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STANDARD C1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

C1.1 Scientific Inquiry

C1.1A Generate new questions that can be investigated in the laboratory or field.

C1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.

C1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).

C1.1D Identify patterns in data and relate them to theoretical models.

C1.1E Describe a reason for a given conclusion using evidence from an investigation.

C1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.

C1.1g Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.

C1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.

C1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.

C1.2 Scientific Reflection and Social Implications

C1.2A Critique whether or not specific questions can be answered through scientific investigations.

C1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.

C1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.

C1.2D Evaluate scientific explanations in a peer review process or discussion format.

C1.2E Evaluate the future career and occupational prospects of science fields.

C1.2f Critique solutions to problems, given criteria and scientific constraints.

C1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.

C1.2h Describe the distinctions between scientific theories, laws, hypotheses, and observations.

C1.2i Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.

C1.2j Apply science principles or scientific data to anticipate effects of technological design decisions.

C1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.

STANDARD C2: FORMS OF ENERGY

P2.p1 Potential Energy (prerequisite)

P2.p1A Describe energy changes associated with changes of state in terms of the arrangement and order of the atoms (molecules) in each state. (prerequisite)

P2.p1B Use the positions and arrangements of atoms and molecules in solid, liquid, and gas state to explain the need for an input of energy for melting and boiling and a release of energy in condensation and freezing. (prerequisite)

C2.1x Chemical Potential Energy

C2.1a Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.

C2.1b Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).

C2.1c Compare qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid.

C2.2 Molecules in Motion

C2.2A Describe conduction in terms of molecules bumping into each other to transfer energy. Explain why there is better conduction in solids and liquids than gases.

C2.2B Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.

C2.2x Molecular Entropy

C2.2c Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.

C2.2d Explain convection and the difference in transfer of thermal energy for solids, liquids, and gases using evidence that molecules are in constant motion.

C2.2e Compare the entropy of solids, liquids, and gases.

C2.2f Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.

C2.3x Breaking Chemical Bonds

C2.3a Explain how the rate of a given chemical reaction is dependent on the temperature and the activation energy.

C2.3b Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.

C2.4x Electron Movement

C2.4a Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions.

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C2.4b Contrast the mechanism of energy changes and the appearance of absorption and emission spectra.

C2.4c Explain why an atom can absorb only certain wavelengths of light.

C2.4d Compare various wavelengths of light (visible and nonvisible) in terms of frequency and relative energy.

C2.5x Nuclear Stability

C2.5a Determine the age of materials using the ratio of stable and unstable isotopes of a particular type.

C2.r5b Illustrate how elements can change in nuclear reactions using balanced equations. (recommended)

C2.r5c Describe the potential energy changes as two protons approach each other. (recommended)

C2.r5d Describe how and where all the elements on earth were formed. (recommended)

STANDARD C3: ENERGY TRANSFER AND CONSERVATION

P3.p1 Conservation of Energy (prerequisite)

P3.p1A Explain that the amount of energy necessary to heat a substance will be the same as the amount of energy released when the substance is cooled to the original temperature. (prerequisite)

C3.1x Hess's Law

C3.1a Calculate the ΔH for a given reaction using Hess's Law.

C3.1b Draw enthalpy diagrams for exothermic and endothermic reactions.

C3.1c Calculate the ΔH for a chemical reaction using simple coffee cup calorimetry.

C3.1d Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.

P3.p2 Energy Transfer (prerequisite)

P3.p2A Trace (or diagram) energy transfers involving various types of energy including nuclear, chemical, electrical, sound, and light. (prerequisite)

C3.2x Enthalpy

C3.2a Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.

C3.2b Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms.

C3.3 Heating Impacts

C3.3A Describe how heat is conducted in a solid.

C3.3B Describe melting on a molecular level.

C3.3x Bond Energy

C3.3c Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond.

C3.4 Endothermic and Exothermic Reactions

C3.4A Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.

C3.4B Explain why chemical reactions will either release or absorb energy.

C3.4x Enthalpy and Entropy

C3.4c Write chemical equations including the heat term as a part of equation or using ΔH notation.

C3.4d Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.

C3.4e Predict if a chemical reaction is spontaneous given the enthalpy (ΔH) and entropy (ΔS) changes for the reaction using Gibb's Free Energy, $\Delta G = \Delta H - T\Delta S$ (Note: mathematical computation of ΔG is not required.)

C3.4f Explain why some endothermic reactions are spontaneous at room temperature.

C3.4g Explain why gases are less soluble in warm water than cold water.

C3.5x Mass Defect

C3.5a Explain why matter is not conserved in nuclear reactions.

STANDARD C4: PROPERTIES OF MATTER

P4.p1 Kinetic Molecular Theory (prerequisite)

P4.p1A For a substance that can exist in all three phases, describe the relative motion of the particles in each of the phases. (prerequisite)

P4.p1B For a substance that can exist in all three phases, make a drawing that shows the arrangement and relative spacing of the particles in each of the phases. (prerequisite)

P4.p1C For a simple compound, present a drawing that shows the number of particles in the system does not change as a result of a phase change. (prerequisite)

P4.p2 Elements, Compounds, and Mixtures (prerequisite)

P4.p2A Distinguish between an element, compound, or mixture based on drawings or formulae. (prerequisite)

P4.p2B Identify a pure substance (element or compound) based on unique chemical and physical properties. (prerequisite)

P4.p2C Separate mixtures based on the differences in physical properties of the individual components. (prerequisite)

P4.p2D Recognize that the properties of a compound differ from those of its individual elements. (prerequisite)

C4.1x Molecular and Empirical Formulae

C4.1a Calculate the percent by weight of each element in a compound based on the compound formula.

C4.1b Calculate the empirical formula of a compound based on the percent by weight of each element in the compound.

C4.1c Use the empirical formula and molecular weight of a compound to determine the molecular formula.

C4.2 Nomenclature

C4.2A Name simple binary compounds using their formulae.

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C4.2B Given the name, write the formula of simple binary compounds.

C4.2x Nomenclature

C4.2c Given a formula, name the compound.

C4.2d Given the name, write the formula of ionic and molecular compounds.

C4.2e Given the formula for a simple hydrocarbon, draw and name the isomers.

C4.3 Properties of Substances

C4.3A Recognize that substances that are solid at room temperature have stronger attractive forces than liquids at room temperature, which have stronger attractive forces than gases at room temperature.

C4.3B Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.

C4.3x Solids

C4.3c Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances.

C4.3d Compare the strength of the forces of attraction between molecules of different elements. (For example, at room temperature, chlorine is a gas and iodine is a solid.)

C4.3e Predict whether the forces of attraction in a solid are primarily metallic, covalent, network covalent, or ionic based upon the elements' location on the periodic table.

C4.3f Identify the elements necessary for hydrogen bonding (N, O, F).

C4.3g Given the structural formula of a compound, indicate all the intermolecular forces present (dispersion, dipolar, hydrogen bonding).

C4.3h Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.

C4.3i Explain why ionic solids have higher melting points than covalent solids. (For example, NaF has a melting point of 995°C, while water has a melting point of 0°C.)

C4.4x Molecular Polarity

C4.4a Explain why at room temperature different compounds can exist in different phases.

C4.4b Identify if a molecule is polar or nonpolar given a structural formula for the compound.

C4.5x Ideal Gas Law

C4.5a Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.

C4.5b Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.

C4.5c Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.

C4.6x Moles

C4.6a Calculate the number of moles of any compound or element given the mass of the substance.

C4.6b Calculate the number of particles of any compound or element given the mass of the substance.

C4.7x Solutions

C4.7a Investigate the difference in the boiling point or freezing point of pure water and a salt solution.

C4.7b Compare the density of pure water to that of a sugar solution.

C4.8 Atomic Structure

C4.8A Identify the location, relative mass, and charge for electrons, protons, and neutrons.

C4.8B Describe the atom as mostly empty space with an extremely small, dense nucleus consisting of the protons and neutrons and an electron cloud surrounding the nucleus.

C4.8C Recognize that protons repel each other and that a strong force needs to be present to keep the nucleus intact.

C4.8D Give the number of electrons and protons present if the fluoride ion has a –1 charge.

C4.8x Electron Configuration

C4.8e Write the complete electron configuration of elements in the first four rows of the periodic table.

C4.8f Write kernel structures for main group elements.

C4.8g Predict oxidation states and bonding capacity for main group elements using their electron structure.

C4.8h Describe the shape and orientation of *s* and *p* orbitals.

C4.8i Describe the fact that the electron location cannot be exactly determined at any given time.

C4.9 Periodic Table

C4.9A Identify elements with similar chemical and physical properties using the periodic table.

C4.9x Electron Energy Levels

C4.9b Identify metals, non-metals, and metalloids using the periodic table.

C4.9c Predict general trends in atomic radius, first ionization energy, and electonegativity of the elements using the periodic table.

C4.10 Neutral Atoms, Ions, and Isotopes

C4.10A List the number of protons, neutrons, and electrons for any given ion or isotope.

C4.10B Recognize that an element always contains the same number of protons.

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C4.10x Average Atomic Mass

C4.10c Calculate the average atomic mass of an element given the percent abundance and mass of the individual isotopes.

C4.10d Predict which isotope will have the greatest abundance given the possible isotopes for an element and the average atomic mass in the periodic table.

C4.10e Write the symbol for an isotope, ${}^{A}_{Z}X$, where *Z* is the atomic number, *A* is the mass number, and *X* is the symbol for the element.

STANDARD C5: CHANGES IN MATTER

P5.p1 Conservation of Matter (prerequisite)

P5.p1A Draw a picture of the particles of an element or compound as a solid, liquid, and gas. (prerequisite)

C5.r1x Rates of Reactions (recommended)

C5.r1a Predict how the rate of a chemical reaction will be influenced by changes in concentration, and temperature, pressure. (recommended)

C5.r1b Explain how the rate of a reaction will depend on concentration, temperature, pressure, and nature of reactant. (recommended)

C5.2 Chemical Changes

C5.2A Balance simple chemical equations applying the conservation of matter.

C5.2B Distinguish between chemical and physical changes in terms of the properties of the reactants and products.

C5.2C Draw pictures to distinguish the relationships between atoms in physical and chemical changes.

C5.2x Balancing Equations

C5.2d Calculate the mass of a particular compound formed from the masses of starting materials.

C5.2e Identify the limiting reagent when given the masses of more than one reactant.

C5.2f Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.

C5.2g Calculate the number of atoms present in a given mass of element.

C5.3x Equilibrium

C5.3a Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).

C5.3b Predict shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).

C5.3c Predict the extent reactants are converted to products using the value of the equilibrium constant.

C5.4 Phase Change/Diagrams

C5.4A Compare the energy required to raise the temperature of one gram of aluminum and one gram of water the same number of degrees.

C5.4B Measure, plot, and interpret the graph of the temperature versus time of an ice-water mixture, under slow heating, through melting and boiling.

C5.4x Changes of State

C5.4c Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g., ammonia and methane).

C5.4d Explain why freezing is an exothermic change of state.

C5.4e Compare the melting point of covalent compounds based on the strength of IMFs (intermolecular forces).

C5.5 Chemical Bonds—Trends

C5.5A Predict if the bonding between two atoms of different elements will be primarily ionic or covalent.

C5.4B Predict the formula for binary compounds of main group elements.

C5.5x Chemical Bonds

C5.5c Draw Lewis structures for simple compounds.

C5.5d Compare the relative melting point, electrical and thermal conductivity and hardness for ionic, metallic, and covalent compounds.

C5.5e Relate the melting point, hardness, and electrical and thermal conductivity of a substance to its structure.

C5.6x Reduction/Oxidation Reactions

C5.6a Balance half-reactions and describe them as oxidations or reductions.

C5.6b Predict single replacement reactions.

C5.6c Explain oxidation occurring when two different metals are in contact.

C5.6d Calculate the voltage for spontaneous redox reactions from the standard reduction potentials.

C5.6e Identify the reactions occurring at the anode and cathode in an electrochemical cell.

C5.7 Acids and Bases

C5.7A Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.

C5.7B Predict products of an acid-base neutralization.

C5.7C Describe tests that can be used to distinguish an acid from a base.

C5.7D Classify various solutions as acidic or basic, given their pH.

C5.7E Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.

C5.7x Bronsted-Lowry

C5.7f Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations.

C5.7g Calculate the pH from the hydronium ion or hydroxide ion concentration.

C5.7h Explain why sulfur oxides and nitrogen oxides contribute to acid rain.

C5.r7i Identify the Brønsted-Lowry conjugate acid-base pairs in an equation. (recommended)

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C5.8 Carbon Chemistry

C5.8A Draw structural formulas for up to ten carbon chains of simple hydrocarbons.

C5.8B Draw isomers for simple hydrocarbons.

C5.8C Recognize that proteins, starches, and other large biological molecules are polymers.

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Section C: ACT's College Readiness Standards Included in Michigan's Grade 8–12 Content Standards and Expectations

In recent years ACT has brought a distinctive voice to the debate on what it means to be truly ready for college. Using a wealth of longitudinal data—data that no one else possesses—ACT has pioneered empirical approaches to assessing students' college readiness. Using thousands of student records and responses, content and measurement experts at ACT have developed detailed statements that describe what students typically know and are able to do at different levels of test performance. These data-driven, empirically derived score descriptors, known as ACT's College Readiness Standards, describe student achievement within various score ranges on the English, Reading, Writing, Mathematics, and Science tests on the EXPLORE, PLAN, and ACT.

In this section (Section C), the ACT College Readiness Standards included in Michigan's Content Standards and Expectations are highlighted. College Readiness Standards not highlighted are those that include specific content, complexity, and/or proficiency level descriptors that ACT content experts determined were not included in Michigan's Content Standards and Expectations.

Table C-1. ACT's College Readiness Standards — English

	Topic Development in Terms of Purpose and Focus	Organization, Unity, and Coherence	Word Choice in Terms of Style, Tone, Clarity, and Economy
13–15		Use conjunctive adverbs or phrases to show time relationships in simple narrative essays (e.g., *then*, *this time*)	Revise sentences to correct awkward and confusing arrangements of sentence elements Revise vague nouns and pronouns that create obvious logic problems
16–19	Identify the basic purpose or role of a specified phrase or sentence Delete a clause or sentence because it is obviously irrelevant to the essay	Select the most logical place to add a sentence in a paragraph	Delete obviously synonymous and wordy material in a sentence Revise expressions that deviate from the style of an essay
20–23	Identify the central idea or main topic of a straightforward piece of writing Determine relevancy when presented with a variety of sentence-level details	Use conjunctive adverbs or phrases to express straightforward logical relationships (e.g., *first*, *afterward*, *in response*) Decide the most logical place to add a sentence in an essay Add a sentence that introduces a simple paragraph	Delete redundant material when information is repeated in different parts of speech (e.g., "alarmingly startled") Use the word or phrase most consistent with the style and tone of a fairly straightforward essay Determine the clearest and most logical conjunction to link clauses
24–27	Identify the focus of a simple essay, applying that knowledge to add a sentence that sharpens that focus or to determine if an essay has met a specified goal Delete material primarily because it disturbs the flow and development of the paragraph Add a sentence to accomplish a fairly straightforward purpose such as illustrating a given statement	Determine the need for conjunctive adverbs or phrases to create subtle logical connections between sentences (e.g., *therefore*, *however*, *in addition*) Rearrange the sentences in a fairly uncomplicated paragraph for the sake of logic Add a sentence to introduce or conclude the essay or to provide a transition between paragraphs when the essay is fairly straightforward	Revise a phrase that is redundant in terms of the meaning and logic of the entire sentence Identify and correct ambiguous pronoun references Use the word or phrase most appropriate in terms of the content of the sentence and tone of the essay
28–32	Apply an awareness of the focus and purpose of a fairly involved essay to determine the rhetorical effect and suitability of an existing phrase or sentence, or to determine the need to delete plausible but irrelevant material Add a sentence to accomplish a subtle rhetorical purpose such as to emphasize, to add supporting detail, or to express meaning through connotation	Make sophisticated distinctions concerning the logical use of conjunctive adverbs or phrases, particularly when signaling a shift between paragraphs Rearrange sentences to improve the logic and coherence of a complex paragraph Add a sentence to introduce or conclude a fairly complex paragraph	Correct redundant material that involves sophisticated vocabulary and sounds acceptable as conversational English (e.g., "an aesthetic viewpoint" versus "the outlook of an aesthetic viewpoint") Correct vague and wordy or clumsy and confusing writing containing sophisticated language
33–36	Determine whether a complex essay has accomplished a specific purpose Add a phrase or sentence to accomplish a complex purpose, often expressed in terms of the main focus of the essay	Consider the need for introductory sentences or transitions, basing decisions on a thorough understanding of both the logic and rhetorical effect of the paragraph and essay	Delete redundant material that involves subtle concepts or that is redundant in terms of the paragraph as a whole

Table C-1. ACT's College Readiness Standards — English (continued)

	Sentence Structure and Formation	Conventions of Usage	Conventions of Punctuation
13–15	Use conjunctions or punctuation to join simple clauses Revise shifts in verb tense between simple clauses in a sentence or between simple adjoining sentences	Solve such basic grammatical problems as how to form the past and past participle of irregular but commonly used verbs and how to form comparative and superlative adjectives	Delete commas that create basic sense problems (e.g., between verb and direct object)
16–19	Determine the need for punctuation and conjunctions to avoid awkward-sounding sentence fragments and fused sentences Decide the appropriate verb tense and voice by considering the meaning of the entire sentence	Solve such grammatical problems as whether to use an adverb or adjective form, how to ensure straightforward subject-verb and pronoun-antecedent agreement, and which preposition to use in simple contexts Recognize and use the appropriate word in frequently confused pairs such as *there* and *their*, *past* and *passed*, and *led* and *lead*	Provide appropriate punctuation in straightforward situations (e.g., items in a series) Delete commas that disturb the sentence flow (e.g., between modifier and modified element)
20–23	Recognize and correct marked disturbances of sentence flow and structure (e.g., participial phrase fragments, missing or incorrect relative pronouns, dangling or misplaced modifiers)	Use idiomatically appropriate prepositions, especially in combination with verbs (e.g., *long for*, *appeal to*) Ensure that a verb agrees with its subject when there is some text between the two	Use commas to set off simple parenthetical phrases Delete unnecessary commas when an incorrect reading of the sentence suggests a pause that should be punctuated (e.g., between verb and direct object clause)
24–27	Revise to avoid faulty placement of phrases and faulty coordination and subordination of clauses in sentences with subtle structural problems Maintain consistent verb tense and pronoun person on the basis of the preceding clause or sentence	Ensure that a pronoun agrees with its antecedent when the two occur in separate clauses or sentences Identify the correct past and past participle forms of irregular and infrequently used verbs and form present-perfect verbs by using *have* rather than *of*	Use punctuation to set off complex parenthetical phrases Recognize and delete unnecessary commas based on a careful reading of a complicated sentence (e.g., between the elements of a compound subject or compound verb joined by *and*) Use apostrophes to indicate simple possessive nouns Recognize inappropriate uses of colons and semicolons
28–32	Use sentence-combining techniques, effectively avoiding problematic comma splices, run-on sentences, and sentence fragments, especially in sentences containing compound subjects or verbs Maintain a consistent and logical use of verb tense and pronoun person on the basis of information in the paragraph or essay as a whole	Correctly use reflexive pronouns, the possessive pronouns *its* and *your*, and the relative pronouns *who* and *whom* Ensure that a verb agrees with its subject in unusual situations (e.g., when the subject-verb order is inverted or when the subject is an indefinite pronoun)	Use commas to set off a nonessential/nonrestrictive appositive or clause Deal with multiple punctuation problems (e.g., compound sentences containing unnecessary commas and phrases that may or may not be parenthetical) Use an apostrophe to show possession, especially with irregular plural nouns Use a semicolon to indicate a relationship between closely related independent clauses
33–36	Work comfortably with long sentences and complex clausal relationships within sentences, avoiding weak conjunctions between independent clauses and maintaining parallel structure between clauses	Provide idiomatically and contextually appropriate prepositions following verbs in situations involving sophisticated language or ideas Ensure that a verb agrees with its subject when a phrase or clause between the two suggests a different number for the verb	Use a colon to introduce an example or an elaboration

Table C-2. ACT's College Readiness Standards — Reading		
	Main Ideas and Author's Approach	**Supporting Details**
13–15	Recognize a clear intent of an author or narrator in uncomplicated literary narratives	Locate basic facts (e.g., names, dates, events) clearly stated in a passage
16–19	Identify a clear main idea or purpose of straightforward paragraphs in uncomplicated literary narratives	Locate simple details at the sentence and paragraph level in uncomplicated passages Recognize a clear function of a part of an uncomplicated passage
20–23	Infer the main idea or purpose of straightforward paragraphs in uncomplicated literary narratives Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in uncomplicated passages	Locate important details in uncomplicated passages Make simple inferences about how details are used in passages
24–27	Identify a clear main idea or purpose of any paragraph or paragraphs in uncomplicated passages Infer the main idea or purpose of straightforward paragraphs in more challenging passages Summarize basic events and ideas in more challenging passages Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in more challenging passages	Locate important details in more challenging passages Locate and interpret minor or subtly stated details in uncomplicated passages Discern which details, though they may appear in different sections throughout a passage, support important points in more challenging passages
28–32	Infer the main idea or purpose of more challenging passages or their paragraphs Summarize events and ideas in virtually any passage Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in virtually any passage	Locate and interpret minor or subtly stated details in more challenging passages Use details from different sections of some complex informational passages to support a specific point or argument
33–36	Identify clear main ideas or purposes of complex passages or their paragraphs	Locate and interpret details in complex passages Understand the function of a part of a passage when the function is subtle or complex

Descriptions of the ACT Reading Passages

Uncomplicated Literary Narratives refers to excerpts from essays, short stories, and novels that tend to use simple language and structure, have a clear purpose and a familiar style, present straightforward interactions between characters, and employ only a limited number of literary devices such as metaphor, simile, or hyperbole.

More Challenging Literary Narratives refers to excerpts from essays, short stories, and novels that tend to make moderate use of figurative language, have a more intricate structure and messages conveyed with some subtlety, and may feature somewhat complex interactions between characters.

Complex Literary Narratives refers to excerpts from essays, short stories, and novels that tend to make generous use of ambiguous language and literary devices, feature complex and subtle interactions between characters, often contain challenging context-dependent vocabulary, and typically contain messages and/or meanings that are not explicit but are embedded in the passage.

Table C-2. ACT's College Readiness Standards — Reading (continued)

	Sequential, Comparative, and Cause-Effect Relationships	Meanings of Words	Generalizations and Conclusions
13–15	Determine when (e.g., first, last, before, after) or if an event occurred in uncomplicated passages Recognize clear cause-effect relationships described within a single sentence in a passage	Understand the implication of a familiar word or phrase and of simple descriptive language	Draw simple generalizations and conclusions about the main characters in uncomplicated literary narratives
16–19	Identify relationships between main characters in uncomplicated literary narratives Recognize clear cause-effect relationships within a single paragraph in uncomplicated literary narratives	Use context to understand basic figurative language	Draw simple generalizations and conclusions about people, ideas, and so on in uncomplicated passages
20–23	Order simple sequences of events in uncomplicated literary narratives Identify clear relationships between people, ideas, and so on in uncomplicated passages Identify clear cause-effect relationships in uncomplicated passages	Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in uncomplicated passages	Draw generalizations and conclusions about people, ideas, and so on in uncomplicated passages Draw simple generalizations and conclusions using details that support the main points of more challenging passages
24–27	Order sequences of events in uncomplicated passages Understand relationships between people, ideas, and so on in uncomplicated passages Identify clear relationships between characters, ideas, and so on in more challenging literary narratives Understand implied or subtly stated cause-effect relationships in uncomplicated passages Identify clear cause-effect relationships in more challenging passages	Use context to determine the appropriate meaning of virtually any word, phrase, or statement in uncomplicated passages Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in more challenging passages	Draw subtle generalizations and conclusions about characters, ideas, and so on in uncomplicated literary narratives Draw generalizations and conclusions about people, ideas, and so on in more challenging passages
28–32	Order sequences of events in more challenging passages Understand the dynamics between people, ideas, and so on in more challenging passages Understand implied or subtly stated cause-effect relationships in more challenging passages	Determine the appropriate meaning of words, phrases, or statements from figurative or somewhat technical contexts	Use information from one or more sections of a more challenging passage to draw generalizations and conclusions about people, ideas, and so on
33–36	Order sequences of events in complex passages Understand the subtleties in relationships between people, ideas, and so on in virtually any passage Understand implied, subtle, or complex cause-effect relationships in virtually any passage	Determine, even when the language is richly figurative and the vocabulary is difficult, the appropriate meaning of context-dependent words, phrases, or statements in virtually any passage	Draw complex or subtle generalizations and conclusions about people, ideas, and so on, often by synthesizing information from different portions of the passage Understand and generalize about portions of a complex literary narrative

Uncomplicated Informational Passages refers to materials that tend to contain a limited amount of data, address basic concepts using familiar language and conventional organizational patterns, have a clear purpose, and are written to be accessible.

More Challenging Informational Passages refers to materials that tend to present concepts that are not always stated explicitly and that are accompanied or illustrated by more—and more detailed—supporting data, include some difficult context-dependent words, and are written in a somewhat more demanding and less accessible style.

Complex Informational Passages refers to materials that tend to include a sizable amount of data, present difficult concepts that are embedded (not explicit) in the text, use demanding words and phrases whose meaning must be determined from context, and are likely to include intricate explanations of processes or events.

Table C-3. ACT's College Readiness Standards — Writing			
	Expressing Judgments	**Focusing on the Topic**	**Developing a Position**
3–4	Show a little understanding of the persuasive purpose of the task but neglect to take or to maintain a position on the issue in the prompt Show limited recognition of the complexity of the issue in the prompt	Maintain a focus on the general topic in the prompt through most of the essay	Offer a little development, with one or two ideas; if examples are given, they are general and may not be clearly relevant; resort often to merely repeating ideas Show little or no movement between general and specific ideas and examples
5–6	Show a basic understanding of the persuasive purpose of the task by taking a position on the issue in the prompt but may not maintain that position Show a little recognition of the complexity of the issue in the prompt by acknowledging, but only briefly describing, a counterargument to the writer's position	Maintain a focus on the general topic in the prompt throughout the essay	Offer limited development of ideas using a few general examples; resort sometimes to merely repeating ideas Show little movement between general and specific ideas and examples
7–8	Show understanding of the persuasive purpose of the task by taking a position on the issue in the prompt Show some recognition of the complexity of the issue in the prompt by • acknowledging counterarguments to the writer's position • providing some response to counter-arguments to the writer's position	Maintain a focus on the general topic in the prompt throughout the essay and attempt a focus on the specific issue in the prompt Present a thesis that establishes focus on the topic	Develop ideas by using some specific reasons, details, and examples Show some movement between general and specific ideas and examples
9–10	Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a broad context for discussion Show recognition of the complexity of the issue in the prompt by • partially evaluating implications and/or complications of the issue, and/or • posing and partially responding to counter-arguments to the writer's position	Maintain a focus on discussion of the specific topic and issue in the prompt throughout the essay Present a thesis that establishes a focus on the writer's position on the issue	Develop most ideas fully, using some specific and relevant reasons, details, and examples Show clear movement between general and specific ideas and examples
11–12	Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a critical context for discussion Show understanding of the complexity of the issue in the prompt by • examining different perspectives, and/or • evaluating implications or complications of the issue, and/or • posing and fully discussing counter-arguments to the writer's position	Maintain a clear focus on discussion of the specific topic and issue in the prompt throughout the essay Present a critical thesis that clearly establishes the focus on the writer's position on the issue	Develop several ideas fully, using specific and relevant reasons, details, and examples Show effective movement between general and specific ideas and examples

Table C-3. ACT's College Readiness Standards — Writing (continued)		
	Organizing Ideas	**Using Language**
3–4	Provide a discernible organization with some logical grouping of ideas in parts of the essay Use a few simple and obvious transitions Present a discernible, though minimally developed, introduction and conclusion	Show limited control of language by • correctly employing some of the conventions of standard English grammar, usage, and mechanics, but with distracting errors that sometimes significantly impede understanding • using simple vocabulary • using simple sentence structure
5–6	Provide a simple organization with logical grouping of ideas in parts of the essay Use some simple and obvious transitional words, though they may at times be inappropriate or misleading Present a discernible, though underdeveloped, introduction and conclusion	Show a basic control of language by • correctly employing some of the conventions of standard English grammar, usage, and mechanics, but with distracting errors that sometimes impede understanding • using simple but appropriate vocabulary • using a little sentence variety, though most sentences are simple in structure
7–8	Provide an adequate but simple organization with logical grouping of ideas in parts of the essay but with little evidence of logical progression of ideas Use some simple and obvious, but appropriate, transitional words and phrases Present a discernible introduction and conclusion with a little development	Show adequate use of language to communicate by • correctly employing many of the conventions of standard English grammar, usage, and mechanics, but with some distracting errors that may occasionally impede understanding • using appropriate vocabulary • using some varied kinds of sentence structures to vary pace
9–10	Provide unity and coherence throughout the essay, sometimes with a logical progression of ideas Use relevant, though at times simple and obvious, transitional words and phrases to convey logical relationships between ideas Present a somewhat developed introduction and conclusion	Show competent use of language to communicate ideas by • correctly employing most conventions of standard English grammar, usage, and mechanics, with a few distracting errors but none that impede understanding • using some precise and varied vocabulary • using several kinds of sentence structures to vary pace and to support meaning
11–12	Provide unity and coherence throughout the essay, often with a logical progression of ideas Use relevant transitional words, phrases, and sentences to convey logical relationships between ideas Present a well-developed introduction and conclusion	Show effective use of language to clearly communicate ideas by • correctly employing most conventions of standard English grammar, usage, and mechanics, with just a few, if any, errors • using precise and varied vocabulary • using a variety of kinds of sentence structures to vary pace and to support meaning

Table C-4. ACT's College Readiness Standards — Mathematics

	Basic Operations & Applications	Probability, Statistics, & Data Analysis	Numbers: Concepts & Properties	Expressions, Equations, & Inequalities
13–15	Perform one-operation computation with whole numbers and decimals Solve problems in one or two steps using whole numbers Perform common conversions (e.g., inches to feet or hours to minutes)	Calculate the average of a list of positive whole numbers Perform a single computation using information from a table or chart	Recognize equivalent fractions and fractions in lowest terms	Exhibit knowledge of basic expressions (e.g., identify an expression for a total as $b + g$) Solve equations in the form $x + a = b$, where a and b are whole numbers or decimals
16–19	Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent Solve some routine two-step arithmetic problems	Calculate the average of a list of numbers Calculate the average, given the number of data values and the sum of the data values Read tables and graphs Perform computations on data from tables and graphs Use the relationship between the probability of an event and the probability of its complement	Recognize one-digit factors of a number Identify a digit's place value	Substitute whole numbers for unknown quantities to evaluate expressions Solve one-step equations having integer or decimal answers Combine like terms (e.g., $2x + 5x$)
20–23	Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average	Calculate the missing data value, given the average and all data values but one Translate from one representation of data to another (e.g., a bar graph to a circle graph) Determine the probability of a simple event Exhibit knowledge of simple counting techniques	Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor	Evaluate algebraic expressions by substituting integers for unknown quantities Add and subtract simple algebraic expressions Solve routine first-degree equations Perform straightforward word-to-symbol translations Multiply two binomials
24–27	Solve multistep arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour)	Calculate the average, given the frequency counts of all the data values Manipulate data from tables and graphs Compute straightforward probabilities for common situations Use Venn diagrams in counting	Find and use the least common multiple Order fractions Work with numerical factors Work with scientific notation Work with squares and square roots of numbers Work problems involving positive integer exponents Work with cubes and cube roots of numbers Determine when an expression is undefined Exhibit some knowledge of the complex numbers	Solve real-world problems using first-degree equations Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions) Identify solutions to simple quadratic equations Add, subtract, and multiply polynomials Factor simple quadratics (e.g., the difference of squares and perfect square trinomials) Solve first-degree inequalities that do not require reversing the inequality sign
28–32	Solve word problems containing several rates, proportions, or percentages	Calculate or use a weighted average Interpret and use information from figures, tables, and graphs Apply counting techniques Compute a probability when the event and/or sample space are not given or obvious	Apply number properties involving prime factorization Apply number properties involving even/odd numbers and factors/multiples Apply number properties involving positive/negative numbers Apply rules of exponents Multiply two complex numbers	Manipulate expressions and equations Write expressions, equations, and inequalities for common algebra settings Solve linear inequalities that require reversing the inequality sign Solve absolute value equations Solve quadratic equations Find solutions to systems of linear equations
33–36	Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings)	Distinguish between mean, median, and mode for a list of numbers Analyze and draw conclusions based on information from figures, tables, and graphs Exhibit knowledge of conditional and joint probability	Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers Exhibit knowledge of logarithms and geometric sequences Apply properties of complex numbers	Write expressions that require planning and/or manipulating to accurately model a situation Write equations and inequalities that require planning, manipulating, and/or solving Solve simple absolute value inequalities

Table C-4. ACT's College Readiness Standards — Mathematics (continued)

	Graphical Representations	Properties of Plane Figures	Measurement	Functions
13–15	Identify the location of a point with a positive coordinate on the number line		Estimate or calculate the length of a line segment based on other lengths given on a geometric figure	
16–19	Locate points on the number line and in the first quadrant	Exhibit some knowledge of the angles associated with parallel lines	Compute the perimeter of polygons when all side lengths are given Compute the area of rectangles when whole number dimensions are given	
20–23	Locate points in the coordinate plane Comprehend the concept of length on the number line Exhibit knowledge of slope	Find the measure of an angle using properties of parallel lines Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90°, 180°, and 360°)	Compute the area and perimeter of triangles and rectangles in simple problems Use geometric formulas when all necessary information is given	Evaluate quadratic functions, expressed in function notation, at integer values
24–27	Identify the graph of a linear inequality on the number line Determine the slope of a line from points or equations Match linear graphs with their equations Find the midpoint of a line segment	Use several angle properties to find an unknown angle measure Recognize Pythagorean triples Use properties of isosceles triangles	Compute the area of triangles and rectangles when one or more additional simple steps are required Compute the area and circumference of circles after identifying necessary information Compute the perimeter of simple composite geometric figures with unknown side lengths	Evaluate polynomial functions, expressed in function notation, at integer values Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths
28–32	Interpret and use information from graphs in the coordinate plane Match number line graphs with solution sets of linear inequalities Use the distance formula Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle)	Apply properties of 30°-60°-90°, 45°-45°-90°, similar, and congruent triangles Use the Pythagorean theorem	Use relationships involving area, perimeter, and volume of geometric figures to compute another measure	Evaluate composite functions at integer values Apply basic trigonometric ratios to solve right-triangle problems
33–36	Match number line graphs with solution sets of simple quadratic inequalities Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$ Solve problems integrating multiple algebraic and/or geometric concepts Analyze and draw conclusions based on information from graphs in the coordinate plane	Draw conclusions based on a set of conditions Solve multistep geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas Use relationships among angles, arcs, and distances in a circle	Use scale factors to determine the magnitude of a size change Compute the area of composite geometric figures when planning or visualization is required	Write an expression for the composite of two simple functions Use trigonometric concepts and basic identities to solve problems Exhibit knowledge of unit circle trigonometry Match graphs of basic trigonometric functions with their equations

Table C-5. ACT's College Readiness Standards — Science

	Interpretation of Data	Scientific Investigation	Evaluation of Models, Inferences, and Experimental Results
13–15	Select a single piece of data (numerical or nonnumerical) from a simple data presentation (e.g., a table or graph with two or three variables; a food web diagram) Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, axis labels)		
16–19	Select two or more pieces of data from a simple data presentation Understand basic scientific terminology Find basic information in a brief body of text Determine how the value of one variable changes as the value of another variable changes in a simple data presentation	Understand the methods and tools used in a simple experiment	
20–23	Select data from a complex data presentation (e.g., a table or graph with more than three variables; a phase diagram) Compare or combine data from a simple data presentation (e.g., order or sum data from a table) Translate information into a table, graph, or diagram	Understand the methods and tools used in a moderately complex experiment Understand a simple experimental design Identify a control in an experiment Identify similarities and differences between experiments	Select a simple hypothesis, prediction, or conclusion that is supported by a data presentation or a model Identify key issues or assumptions in a model
24–27	Compare or combine data from two or more simple data presentations (e.g., categorize data from a table using a scale from another table) Compare or combine data from a complex data presentation Interpolate between data points in a table or graph Determine how the value of one variable changes as the value of another variable changes in a complex data presentation Identify and/or use a simple (e.g., linear) mathematical relationship between data Analyze given information when presented with new, simple information	Understand the methods and tools used in a complex experiment Understand a complex experimental design Predict the results of an additional trial or measurement in an experiment Determine the experimental conditions that would produce specified results	Select a simple hypothesis, prediction, or conclusion that is supported by two or more data presentations or models Determine whether given information supports or contradicts a simple hypothesis or conclusion, and why Identify strengths and weaknesses in one or more models Identify similarities and differences between models Determine which model(s) is(are) supported or weakened by new information Select a data presentation or a model that supports or contradicts a hypothesis, prediction, or conclusion
28–32	Compare or combine data from a simple data presentation with data from a complex data presentation Identify and/or use a complex (e.g., nonlinear) mathematical relationship between data Extrapolate from data points in a table or graph	Determine the hypothesis for an experiment Identify an alternate method for testing a hypothesis	Select a complex hypothesis, prediction, or conclusion that is supported by a data presentation or model Determine whether new information supports or weakens a model, and why Use new information to make a prediction based on a model
33–36	Compare or combine data from two or more complex data presentations Analyze given information when presented with new, complex information	Understand precision and accuracy issues Predict how modifying the design or methods of an experiment will affect results Identify an additional trial or experiment that could be performed to enhance or evaluate experimental results	Select a complex hypothesis, prediction, or conclusion that is supported by two or more data presentations or models Determine whether given information supports or contradicts a complex hypothesis or conclusion, and why

Science College Readiness Standards are measured in the context of science topics students encounter in science courses. These topics may include:

Life Science/Biology	Physical Science/Chemistry, Physics	Earth & Space Science
• Animal behavior • Animal development and growth • Body systems • Cell structure and processes • Ecology • Evolution • Genetics • Homeostasis • Life cycles • Molecular basis of heredity • Origin of life • Photosynthesis • Plant development, growth, structure • Populations • Taxonomy	• Atomic structure • Chemical bonding, equations, nomenclature, reactions • Electrical circuits • Elements, compounds, mixtures • Force and motions • Gravitation • Heat and work • Kinetic and potential energy • Magnetism • Momentum • The Periodic Table • Properties of solutions • Sound and light • States, classes, and properties of matter • Waves	• Earthquakes and volcanoes • Earth's atmosphere • Earth's resources • Fossils and geological time • Geochemical cycles • Groundwater • Lakes, rivers, oceans • Mass movements • Plate tectonics • Rocks, minerals • Solar system • Stars, galaxies, and the universe • Water cycle • Weather and climate • Weathering and erosion

Section D: ACT's WorkKeys Skills Included in Michigan's Content Standards and Expectations

Working with Charter States, national education organizations, educators, employers, and experts in employment and training requirements, ACT identified workplace skills that help individuals successfully perform a wide range of jobs. These skills form the basis of the WorkKeys assessments.

In this section (Section D), the WorkKeys Skills that are highlighted are those that are included in Michigan's Content Standards and Expectations. WorkKeys Skills not highlighted are those statements that include specific content, complexity and/or proficiency level descriptions that were not described in Michigan's Content Standards and Expectations.

Because Michigan educators are the experts on the Michigan Content Standards and Expectations, we would strongly encourage them to examine this document and offer their interpretations.

WorkKeys Skills

Level	Reading for Information	Applied Mathematics	Locating Information
3	Identify main ideas and clearly stated details Choose the correct meaning of a word that is clearly defined in the reading Choose the correct meaning of common, everyday and workplace words Choose when to perform each step in a short series of steps Apply instructions to a situation that is the same as the one in the reading materials	Solve problems that require a single type of mathematics operation (addition, subtraction, multiplication, and division) using whole numbers Add or subtract negative numbers Change numbers from one form to another using whole numbers, fractions, decimals, or percentages Convert simple money and time units (e.g., hours to minutes)	Find one or two pieces of information in a graphic Fill in one or two pieces of information that are missing from a graphic
4	Identify important details that may not be clearly stated Use the reading material to figure out the meaning of words that are not defined Apply instructions with several steps to a situation that is the same as the situation in the reading materials Choose what to do when changing conditions call for a different action (follow directions that include "if-then" statements)	Solve problems that require one or two operations Multiply negative numbers Calculate averages, simple ratios, simple proportions, or rates using whole numbers and decimals Add commonly known fractions, decimals, or percentages (e.g., ½, .75, 25%) Add three fractions that share a common denominator Multiply a mixed number by a whole number or decimal Put the information in the right order before performing calculations	Find several pieces of information in one or two graphics Understand how graphics are related to each other Summarize information from one or two straightforward graphics Identify trends shown in one or two straightforward graphics Compare information and trends shown in one or two straightforward graphics
5	Figure out the correct meaning of a word based on how the word is used Identify the correct meaning of an acronym that is defined in the document Identify the paraphrased definition of a technical term or jargon that is defined in the document Apply technical terms and jargon and relate them to stated situations Apply straightforward instructions to a new situation that is similar to the one described in the material Apply complex instructions that include conditionals to situations described in the materials	Decide what information, calculations, or unit conversions to use to solve the problem Look up a formula and perform single-step conversions within or between systems of measurement Calculate using mixed units (e.g., 3.5 hours and 4 hours 30 minutes) Divide negative numbers Find the best deal using one- and two-step calculations and then comparing results Calculate perimeters and areas of basic shapes (rectangles and circles) Calculate percentage discounts or markups	Sort through distracting information Summarize information from one or more detailed graphics Identify trends shown in one or more detailed or complicated graphics Compare information and trends from one or more complicated graphics
6	Identify implied details Use technical terms and jargon in new situations Figure out the less common meaning of a word based on the context Apply complicated instructions to new situations Figure out the principles behind policies, rules, and procedures Apply general principles from the materials to similar and new situations Explain the rationale behind a procedure, policy, or communication	Use fractions, negative numbers, ratios, percentages, or mixed numbers Rearrange a formula before solving a problem Use two formulas to change from one unit to another within the same system of measurement Use two formulas to change from one unit in one system of measurement to a unit in another system of measurement Find mistakes in items that belong at Levels 3, 4, and 5 Find the best deal and use the result for another calculation Find areas of basic shapes when it may be necessary to rearrange the formula, convert units of measurement in the calculations, or use the result in further calculations Find the volume of rectangular solids Calculate multiple rates	Draw conclusions based on one complicated graphic or several related graphics Apply information from one or more complicated graphics to specific situations Use the information to make decisions
7	Figure out the definitions of difficult, uncommon words based on how they are used Figure out the meaning of jargon or technical terms based on how they are used Figure out the general principles behind the policies and apply them to situations that are quite different from any described in the materials	Solve problems that include nonlinear functions and/or that involve more than one unknown Find mistakes in Level 6 items Convert between systems of measurement that involve fractions, mixed numbers, decimals, and/or percentages Calculate multiple areas and volumes of spheres, cylinders, or cones Set up and manipulate complex ratios or proportions Find the best deal when there are several choices Apply basic statistical concepts	