Checklist

Manhattan Beach
Unified School District

CONTENT STANDARDS

GRADE NINE

ENGLISH-LANGUAGE ARTS

MATHEMATICS

SCIENCE

(HISTORY-SOCIAL SCIENCE)

ENGLISH-LANGUAGE ARTS CONTENT STANDARDS

GRADES NINE AND TEN

READING

1.0 Word Analysis, Fluency, and Systematic Vocabulary Development

Vocabulary and Concept Development

	1.1	Identify and use the literal and figurative meanings of words and understand word derivations. **(CAHSEE)**
	1.2	Distinguish between the denotative and connotative meanings of words and interpret the connotative power of words.
	1.3	Identify Greek, Roman, and Norse mythology and use the knowledge to understand the origin and meaning of new words (e.g., the word narcissistic drawn from the myth of Narcissus and Echo).

2.0 Reading Comprehension (Focus on Informational Materials)

Structural Features of Informational Materials

	2.1	Analyze the structure and format of functional workplace documents, including the graphics and headers, and explain how authors use the features to achieve their purposes.
	2.2	Prepare a bibliography of reference materials for a report using a variety of consumer, workplace, and public documents.

Comprehension and Analysis of Grade-Level-Appropriate Text

	2.3	Generate relevant questions about readings on issues that can be researched.
	2.4	Synthesize the content from several sources or works by a single author dealing with a single issue; paraphrase the ideas and connect them to other sources and related topics to demonstrate comprehension. **(CAHSEE)**
	2.5	Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.
	2.6	Demonstrate use of sophisticated learning tools by following technical directions (e.g., those found with graphic calculators and specialized software programs and in access guides to World Wide Web sites on the Internet) . **(CAHSEE)**

Expository Critique

	2.7	Critique the logic of functional documents by examining the sequence of information and procedures in anticipation of possible reader misunderstandings.
	2.8	Evaluate the credibility of an author's argument or defense of a claim by critiquing the relationship between generalizations and evidence, the comprehensiveness of evidence, and the way in which the author's intent affects the structure and tone of the text (e.g., in professional journals, editorials, political speeches, primary source material).

3.0 Literary Response and Analysis

Structural Features of Literature

	3.1	Articulate the relationship between the expressed purposes and the characteristics of different forms of dramatic literature (e.g., comedy, tragedy, drama, dramatic monologue).
	3.2	Compare and contrast the presentation of a similar theme or topic across genres to explain how the selection of genre shapes the theme or topic.

Narrative Analysis of Grade-Level-Appropriate Text

	3.3	Analyze interactions between main and subordinate characters in a literary text (e.g., internal and external conflicts, motivations, relationships, influences) and explain the way those interactions affect the plot. **(CAHSEE)**
	3.4	Determine characters' traits by what the characters say about themselves in narration, dialogue, dramatic monologue, and soliloquy. **(CAHSEE)**
	3.5	Compare works that express a universal theme and provide evidence to support the ideas expressed in each work.
	3.6	Analyze and trace an author's development of time and sequence, including the use of complex literary devices (e.g., foreshadowing, flashbacks).
	3.7	Recognize and understand the significance of various literary devices, including figurative language, imagery, allegory, and symbolism, and explain their appeal.
	3.8	Interpret and evaluate the impact of ambiguities, subtleties, contradictions, ironies, and incongruities in a text.
	3.9	Explain how voice, persona, and the choice of a narrator affect characterization and the tone, plot, and credibility of a text.
	3.10	Identify and describe the function of dialogue, scene designs, soliloquies, asides, and character foils in dramatic literature.

Literary Criticism

	3.11	Evaluate the aesthetic qualities of style, including the impact of diction and figurative language on tone, mood, and theme, using the terminology of literary criticism. (Aesthetic approach)
	3.12	Analyze the way in which a work of literature is related to the themes and issues of its historical period. (Historical approach) **(CAHSEE)**

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ENGLISH-LANGUAGE ARTS CONTENT STANDARDS continued

GRADES NINE AND TEN

WRITING

1.0 Writing Strategies

Organization and Focus

	1.1	Establish a controlling impression or coherent thesis that conveys a clear and distinctive perspective on the subject and maintain a consistent tone and focus throughout the piece of writing.
	1.2	Use precise language, action verbs, sensory details, appropriate modifiers, and the active rather than the passive voice. **(CAHSEE)**

Research and Technology

	1.3	Use clear research questions and suitable research methods (e.g., library, electronic media, personal interview) to elicit and present evidence from primary and secondary sources.
	1.4	Develop the main ideas within the body of the composition through supporting evidence (e.g., scenarios, commonly held beliefs, hypotheses, definitions).
	1.5	Synthesize information from multiple sources and identify complexities and discrepancies in the information and the different perspectives found in each medium (e.g., almanacs, microfiche, news sources, in-depth field studies, speeches, journals, technical documents).
	1.6	Integrate quotations and citations into a written text while maintaining the flow of ideas.
	1.7	Use appropriate conventions for documentation in the text, notes, and bibliographies by adhering to those in style manuals (e.g*., Modern Language Association Handbook*, *The Chicago Manual of Style*).
	1.8	Design and publish documents by using advanced publishing software and graphic programs.

Evaluation and Revision

	1.9	Revise writing to improve the logic and coherence of the organization and controlling perspective, the precision of word choice, and the tone by taking into consideration the audience, purpose, and formality of the context. **(CAHSEE)**

2.0 Writing Applications (Genres and Their Characteristics)

Using the writing strategies of grades nine and ten outlined in Writing Standard 1.0, students:

	2.1	Write biographical or autobiographical narratives or short stories: a. Relate a sequence of events and communicate the significance of the events to the audience. b. Locate scenes and incidents in specific places. c. Describe with concrete sensory details the sights, sounds, and smells of a scene and the specific actions, movements, gestures, and feelings of the characters; use interior monologue to depict the characters' feelings. d. Pace the presentation of actions to accommodate changes in time and mood. e. Make effective use of descriptions of appearance, images, shifting perspectives, and sensory details. **(CAHSEE)**
	2.2	Write responses to literature: a. Demonstrate a comprehensive grasp of the significant ideas of literary works. b. Support important ideas and viewpoints through accurate and detailed references to the text or to other works. c. Demonstrate awareness of the author's use of stylistic devices and an appreciation of the effects created. d. Identify and assess the impact of perceived ambiguities, nuances, and complexities within the text. **(CAHSEE)**
	2.3	Write expository compositions, including analytical essays and research reports: a. Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives. b. Convey information and ideas from primary and secondary sources accurately and coherently. c. Make distinctions between the relative value and significance of specific data, facts, and ideas. d. Include visual aids by employing appropriate technology to organize and record information on charts, maps, and graphs. e. Anticipate and address readers' potential misunderstandings, biases, and expectations. f. Use technical terms and notations accurately.
	2.4	Write persuasive compositions: a. Structure ideas and arguments in a sustained and logical fashion. b. Use specific rhetorical devices to support assertions (e.g., appeal to logic through reasoning; appeal to emotion or ethical belief; relate a personal anecdote, case study, or analogy). c. Clarify and defend positions with precise and relevant evidence, including facts, expert opinions, quotations, and expressions of commonly accepted beliefs and logical reasoning. d. Address readers' concerns, counterclaims, biases, and expectations.

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ENGLISH-LANGUAGE ARTS CONTENT STANDARDS continued

GRADES NINE AND TEN

WRITING continued

2.0 Writing Applications (Genres and Their Characteristics) continued

Using the writing strategies of grades nine and ten outlined in Writing Standard 1.0, students:

	2.5	Write business letters: a. Provide clear and purposeful information and address the intended audience appropriately. b. Use appropriate vocabulary, tone, and style to take into account the nature of the relationship with, and the knowledge and interests of, the recipients. c. Highlight central ideas or images. d. Follow a conventional style with page formats, fonts, and spacing that contribute to the documents' readability and impact. **(CAHSEE)**
	2.6	Write technical documents (e.g., a manual on rules of behavior for conflict resolution, procedures for conducting a meeting, minutes of a meeting): a. Report information and convey ideas logically and correctly. b. Offer detailed and accurate specifications. c. Include scenarios, definitions, and examples to aid comprehension (e.g., troubleshooting guide). d. Anticipate readers' problems, mistakes, and misunderstandings.

WRITTEN AND ORAL ENGLISH LANGUAGE CONVENTIONS

1.0 Written and Oral English Language Conventions

Grammar and Mechanics of Writing

	1.1	Identify and correctly use clauses (e.g., main and subordinate), phrases (e.g., gerund, infinitive, and participial), and mechanics of punctuation (e.g., semicolons, colons, ellipses, hyphens).
	1.2	Understand sentence construction (e.g., parallel structure, subordination, proper placement of modifiers) and proper English usage (e.g., consistency of verb tenses).
	1.3	Demonstrate an understanding of proper English usage and control of grammar, paragraph and sentence structure, diction, and syntax. **(CAHSEE)**

Manuscript Form

	1.4	Produce legible work that shows accurate spelling and correct use of the conventions of punctuation and capitalization. **(CAHSEE)**
	1.5	Reflect appropriate manuscript requirements, including title page presentation, pagination, spacing and margins, and integration of source and support material (e.g., in-text citation, use of direct quotations, paraphrasing) with appropriate citations.

LISTENING AND SPEAKING

1.0 Listening and Speaking Strategies

Comprehension

	1.1	Formulate judgments about the ideas under discussion and support those judgments with convincing evidence.
	1.2	Compare and contrast the ways in which media genres (e.g., televised news, news magazines, documentaries, online information) cover the same event.

Organization and Delivery of Oral Communication

	1.3	Choose logical patterns of organization (e.g., chronological, topical, cause and effect) to inform and to persuade, by soliciting agreement or action, or to unite audiences behind a common belief or cause.
	1.4	Choose appropriate techniques for developing the introduction and conclusion (e.g., by using literary quotations, anecdotes, references to authoritative sources).
	1.5	Recognize and use elements of classical speech forms (e.g., introduction, first and second transitions, body, conclusion) in formulating rational arguments and applying the art of persuasion and debate.
	1.6	Present and advance a clear thesis statement and choose appropriate types of proof (e.g., statistics, testimony, specific instances) that meet standard tests for evidence, including credibility, validity, and relevance.
	1.7	Use props, visual aids, graphs, and electronic media to enhance the appeal and accuracy of presentations.
	1.8	Produce concise notes for extemporaneous delivery.
	1.9	Analyze the occasion and the interests of the audience and choose effective verbal and nonverbal techniques (e.g., voice, gestures, eye contact) for presentations.

Analysis and Evaluation of Oral and Media Communications

	1.10	Analyze historically significant speeches (e.g., Abraham Lincoln's "Gettysburg Address," Martin Luther King, Jr.'s "I Have a Dream") to find the rhetorical devices and features that make them memorable.
	1.11	Assess how language and delivery affect the mood and tone of the oral communication and make an impact on the audience.
	1.12	Evaluate the clarity, quality, effectiveness, and general coherence of a speaker's important points, arguments, evidence, organization of ideas, delivery, diction, and syntax.

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ENGLISH-LANGUAGE ARTS CONTENT STANDARDS continued

GRADES NINE AND TEN

LISTENING AND SPEAKING continued

1.0 Listening and Speaking Strategies continued

Analysis and Evaluation of Oral and Media Communications continued

	1.13	Analyze the types of arguments used by the speaker, including argument by causation, analogy, authority, emotion, and logic.
	1.14	Identify the aesthetic effects of a media presentation and evaluate the techniques used to create them (e.g., compare Shakespeare's Henry V with Kenneth Branagh's 1990 film version).

2.0 Speaking Applications (Genres and Their Characteristics)

Using the speaking strategies of grades nine and ten outlined in Listening and Speaking Standard 1.0, students:

	2.1	Deliver narrative presentations: a. Narrate a sequence of events and communicate their significance to the audience. b. Locate scenes and incidents in specific places. c. Describe with concrete sensory details the sights, sounds, and smells of a scene and the specific actions, movements, gestures, and feelings of characters. d. Pace the presentation of actions to accommodate time or mood changes.
	2.2	Deliver expository presentations: a. Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives. b. Convey information and ideas from primary and secondary sources accurately and coherently. c. Make distinctions between the relative value and significance of specific data, facts, and ideas. d. Include visual aids by employing appropriate technology to organize and display information on charts, maps, and graphs. e. Anticipate and address the listener's potential misunderstandings, biases, and expectations. f. Use technical terms and notations accurately.
	2.3	Apply appropriate interviewing techniques: a. Prepare and ask relevant questions. b. Make notes of responses. c. Use language that conveys maturity, sensitivity, and respect. d. Respond correctly and effectively to questions. e. Demonstrate knowledge of the subject or organization. f. Compile and report responses. g. Evaluate the effectiveness of the interview.
	2.4	Deliver oral responses to literature: a. Advance a judgment demonstrating a comprehensive grasp of the significant ideas of works or passages (i.e., make and support warranted assertions about the text). b. Support important ideas and viewpoints through accurate and detailed references to the text or to other works. c. Demonstrate awareness of the author's use of stylistic devices and an appreciation of the effects created. d. Identify and assess the impact of perceived ambiguities, nuances, and complexities within the text.
	2.5	Deliver persuasive arguments (including evaluation and analysis of problems and solutions and causes and effects): a. Structure ideas and arguments in a coherent, logical fashion. b. Use rhetorical devices to support assertions (e.g., by appeal to logic through reasoning; by appeal to emotion or ethical belief; by use of personal anecdote, case study, or analogy). c. Clarify and defend positions with precise and relevant evidence, including facts, expert opinions, quotations, expressions of commonly accepted beliefs, and logical reasoning. d. Anticipate and address the listener's concerns and counterarguments.
	2.6	Deliver descriptive presentations: a. Establish clearly the speaker's point of view on the subject of the presentation. b. Establish clearly the speaker's relationship with that subject (e.g., dispassionate observation, personal involvement). c. Use effective, factual descriptions of appearance, concrete images, shifting perspectives and vantage points, and sensory details.

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MATHEMATICS CONTENT STANDARDS

GRADES EIGHT THROUGH TWELVE

ALGEBRA I

	1.0	Students identify and use the arithmetic properties of subsets of integers and rational, irrational, and real numbers, including closure properties for the four basic arithmetic operations where applicable: 1.1 Students use properties of numbers to demonstrate whether assertions are true or false.
	2.0	Students understand and use such operations as taking the opposite, finding the reciprocal, taking a root, and raising to a fractional power. They understand and use the rules of exponents. **(CAHSEE)**
	3.0	Students solve equations and inequalities involving absolute values. **(CAHSEE)**
	4.0	Students simplify expressions before solving linear equations and inequalities in one variable, such as $3(2x-5) + 4(x-2) = 12$. **(CAHSEE)**
	5.0	Students solve multi-step problems, including word problems, involving linear equations and linear inequalities in one variable and provide justification for each step. **(CAHSEE)**
	6.0	Students graph a linear equation and compute the x- and y-intercepts (e.g., graph $2x + 6y = 4$). They are also able to sketch the region defined by linear inequality (e.g., they sketch the region defined by $2x + 6y < 4$). **(CAHSEE)**
	7.0	Students verify that a point lies on a line, given an equation of the line. Students are able to derive linear equations by using the point-slope formula. **(CAHSEE)**
	8.0	Students understand the concepts of parallel lines and perpendicular lines and how those slopes are related. Students are able to find the equation of a line perpendicular to a given line that passes through a given point. **(CAHSEE)**
	9.0	Students solve a system of two linear equations in two variables algebraically and are able to interpret the answer graphically. Students are able to solve a system of two linear inequalities in two variables and to sketch the solution sets. **(CAHSEE)**
	10.0	Students add, subtract, multiply, and divide monomials and polynomials. Students solve multi-step problems, including word problems, by using these techniques. **(CAHSEE)**
	11.0	Students apply basic factoring techniques to second- and simple third-degree polynomials. These techniques include finding a common factor for all terms in a polynomial, recognizing the difference of two squares, and recognizing perfect squares of binomials.
	12.0	Students simplify fractions with polynomials in the numerator and denominator by factoring both and reducing them to the lowest terms.
	13.0	Students add, subtract, multiply, and divide rational expressions and functions. Students solve both computationally and conceptually challenging problems by using these techniques.
	14.0	Students solve a quadratic equation by factoring or completing the square.
	15.0	Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems. **(CAHSEE)**
	16.0	Students understand the concepts of a relation and a function, determine whether a given relation defines a function, and give pertinent information about given relations and functions.
	17.0	Students determine the domain of independent variables and the range of de-pendent variables defined by a graph, a set of ordered pairs, or a symbolic expression. **(CAHSEE)**
	18.0	Students determine whether a relation defined by a graph, a set of ordered pairs, or a symbolic expression is a function and justify the conclusion.
	19.0	Students know the quadratic formula and are familiar with its proof by completing the square.
	20.0	Students use the quadratic formula to find the roots of a second-degree polynomial and to solve quadratic equations.
	21.0	Students graph quadratic functions and know that their roots are the *x*-intercepts. **(CAHSEE)**
	22.0	Students use the quadratic formula or factoring techniques or both to determine whether the graph of a quadratic function will intersect the *x*-axis in zero, one, or two points.
	23.0	Students apply quadratic equations to physical problems, such as the motion of an object under the force of gravity.
	24.0	Students use and know simple aspects of a logical argument: 24.1 Students explain the difference between inductive and deductive reasoning and identify and provide examples of each. 24.2 Students identify the hypothesis and conclusion in logical deduction. 24.3 Students use counterexamples to show that an assertion is false and recognize that a single counterexample is sufficient to refute an assertion.
	25.0	Students use properties of the number system to judge the validity of results, to justify each step of a procedure, and to prove or disprove statements: 25.1 Students use properties of numbers to construct simple, valid arguments (direct and indirect) for, or formulate counterexamples to, claimed assertions. 25.2 Students judge the validity of an argument according to whether the properties of the real number system and the order of operations have been applied correctly at each step. 25.3 Given a specific algebraic statement involving linear, quadratic, or absolute value expressions or equations or inequalities, students determine whether the statement is true sometimes, always, or never.

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MATHEMATICS CONTENT STANDARDS continued

GRADES EIGHT THROUGH TWELVE

GEOMETRY

	1.0	1.0 Students demonstrate understanding by identifying and giving examples of undefined terms, axioms, theorems, and inductive and deductive reasoning.
	2.0	Students write geometric proofs, including proofs by contradiction.
	3.0	Students construct and judge the validity of a logical argument and give counterexamples to disprove a statement.
	4.0	Students prove basic theorems involving congruence and similarity.
	5.0	Students prove that triangles are congruent or similar, and they are able to use the concept of corresponding parts of congruent triangles.
	6.0	Students know and are able to use the triangle inequality theorem.
	7.0	Students prove and use theorems involving the properties of parallel lines cut by a transversal, the properties of quadrilaterals, and the properties of circles.
	8.0	Students know, derive, and solve problems involving the perimeter, circumference, area, volume, lateral area, and surface area of common geometric figures.
	9.0	Students compute the volumes and surface areas of prisms, pyramids, cylinders, cones, and spheres; and students commit to memory the formulas for prisms, pyramids, and cylinders.
	10.0	Students compute areas of polygons, including rectangles, scalene triangles, equilateral triangles, rhombi, parallelograms, and trapezoids.
	11.0	Students determine how changes in dimensions affect the perimeter, area, and volume of common geometric figures and solids.
	12.0	Students find and use measures of sides and of interior and exterior angles of triangles and polygons to classify figures and solve problems.
	13.0	Students prove relationships between angles in polygons by using properties of complementary, supplementary, vertical, and exterior angles.
	14.0	Students prove the Pythagorean theorem.
	15.0	Students use the Pythagorean theorem to determine distance and find missing lengths of sides of right triangles.
	16.0	Students perform basic constructions with a straightedge and compass, such as angle bisectors, perpendicular bisectors, and the line parallel to a given line through a point off the line.
	17.0	Students prove theorems by using coordinate geometry, including the midpoint of a line segment, the distance formula, and various forms of equations of lines and circles.
	18.0	Students know the definitions of the basic trigonometric functions defined by the angles of a right triangle. They also know and are able to use elementary relationships between them. For example, $\tan(x) = \sin(x)/\cos(x)$, $(\sin(x))^2 + (\cos(x))^2 = 1$.
	19.0	Students use trigonometric functions to solve for an unknown length of a side of a right triangle, given an angle and a length of a side.
	20.0	Students know and are able to use angle and side relationships in problems with special right triangles, such as 30°, 60°, and 90° triangles and 45°, 45°, and 90° triangles.
	21.0	Students prove and solve problems regarding relationships among chords, secants, tangents, inscribed angles, and inscribed and circumscribed polygons of circles.
	22.0	Students know the effect of rigid motions on figures in the coordinate plane and space, including rotations, translations, and reflections.

ALGEBRA II

	1.0	Students solve equations and inequalities involving absolute value.
	2.0	Students solve systems of linear equations and inequalities (in two or three variables) by substitution, with graphs, or with matrices.
	3.0	Students are adept at operations on polynomials, including long division.
	4.0	Students factor polynomials representing the difference of squares, perfect square trinomials, and the sum and difference of two cubes.
	5.0	Students demonstrate knowledge of how real and complex numbers are related both arithmetically and graphically. In particular, they can plot complex numbers as points in the plane.
	6.0	Students add, subtract, multiply, and divide complex numbers.
	7.0	Students add, subtract, multiply, divide, reduce, and evaluate rational expressions with monomial and polynomial denominators and simplify complicated rational expressions, including those with negative exponents in the denominator.
	8.0	Students solve and graph quadratic equations by factoring, completing the square, or using the quadratic formula. Students apply these techniques in solving word problems. They also solve quadratic equations in the complex number system.
	9.0	Students demonstrate and explain the effect that changing a coefficient has on the graph of quadratic functions; that is, students can determine how the graph of a parabola changes as a, b, and c vary in the equation $y = a(x-b) 2 + c$.
	10.0	Students graph quadratic functions and determine the maxima, minima, and zeros of the function.
	11.0	Students prove simple laws of logarithms. 11.1 Students understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents. 11.2 Students judge the validity of an argument according to whether the properties of real numbers, exponents, and logarithms have been applied correctly at each step.

MATHEMATICS CONTENT STANDARDS continued

GRADES EIGHT THROUGH TWELVE

ALGEBRA II continued

	12.0	Students know the laws of fractional exponents, understand exponential functions, and use these functions in problems involving exponential growth and decay.
	13.0	Students use the definition of logarithms to translate between logarithms in any base.
	14.0	Students understand and use the properties of logarithms to simplify logarithmic numeric expressions and to identify their approximate values.
	15.0	Students determine whether a specific algebraic statement involving rational expressions, radical expressions, or logarithmic or exponential functions is sometimes true, always true, or never true.
	16.0	Students demonstrate and explain how the geometry of the graph of a conic section (e.g., asymptotes, foci, eccentricity) depends on the coefficients of the quadratic equation representing it.
	17.0	Given a quadratic equation of the form $ax^2 + by^2 + cx + dy + e = 0$, students can use the method for completing the square to put the equation into standard form and can recognize whether the graph of the equation is a circle, ellipse, parabola, or hyperbola. Students can then graph the equation.
	18.0	Students use fundamental counting principles to compute combinations and permutations.
	19.0	Students use combinations and permutations to compute probabilities.
	20.0	Students know the binomial theorem and use it to expand binomial expressions that are raised to positive integer powers.
	21.0	Students apply the method of mathematical induction to prove general statements about the positive integers.
	22.0	Students find the general term and the sums of arithmetic series and of both finite and infinite geometric series.
	23.0	Students derive the summation formulas for arithmetic series and for both finite and infinite geometric series.
	24.0	Students solve problems involving functional concepts, such as composition, defining the inverse function and performing arithmetic operations on functions.
	25.0	Students use properties from number systems to justify steps in combining and simplifying functions.

TRIGONOMETRY

	1.0	Students understand the notion of angle and how to measure it, in both degrees and radians. They can convert between degrees and radians.
	2.0	Students know the definition of sine and cosine as y- and x-coordinates of points on the unit circle and are familiar with the graphs of the sine and cosine functions.
	3.0	Students know the identity $\cos^2(x) + \sin^2(x) = 1$: 3.1 Students prove that this identity is equivalent to the Pythagorean theorem (i.e., students can prove this identity by using the Pythagorean theorem and, conversely, they can prove the Pythagorean theorem as a consequence of this identity). 3.2 Students prove other trigonometric identities and simplify others by using the identity $\cos^2(x) + \sin^2(x) = 1$. For example, students use this identity to prove that $\sec^2(x) = \tan^2(x) + 1$.
	4.0	Students graph functions of the form $f(t) = A \sin(Bt + C)$ or $f(t) = A \cos(Bt + C)$ and interpret *A, B,* and *C* in terms of amplitude, frequency, period, and phase shift.
	5.0	Students know the definitions of the tangent and cotangent functions and can graph them.
	6.0	Students know the definitions of the secant and cosecant functions and can graph them.
	7.0	Students know that the tangent of the angle that a line makes with the *x*-axis is equal to the slope of the line.
	8.0	Students know the definitions of the inverse trigonometric functions and can graph the functions.
	9.0	Students compute, by hand, the values of the trigonometric functions and the inverse trigonometric functions at various standard points.
	10.0	Students demonstrate an understanding of the addition formulas for sines and cosines and their proofs and can use those formulas to prove and/or simplify other trigonometric identities.
	11.0	Students demonstrate an understanding of half-angle and double-angle formulas for sines and cosines and can use those formulas to prove and/or simplify other trigonometric identities.
	12.0	Students use trigonometry to determine unknown sides or angles in right triangles.
	13.0	Students know the law of sines and the law of cosines and apply those laws to solve problems.
	14.0	Students determine the area of a triangle, given one angle and the two adjacent sides.
	15.0	Students are familiar with polar coordinates. In particular, they can determine polar coordinates of a point given in rectangular coordinates and vice versa.
	16.0	Students represent equations given in rectangular coordinates in terms of polar coordinates.
	17.0	Students are familiar with complex numbers. They can represent a complex number in polar form and know how to multiply complex numbers in their polar form.
	18.0	Students know DeMoivre's theorem and can give nth roots of a complex number given in polar form.
	19.0	Students are adept at using trigonometry in a variety of applications and word problems.

MATHEMATICS CONTENT STANDARDS continued

GRADES EIGHT THROUGH TWELVE

MATHEMATICAL ANALYSIS

	1.0	Students are familiar with, and can apply, polar coordinates and vectors in the plane. In particular, they can translate between polar and rectangular coordinates and can interpret polar coordinates and vectors graphically.
	2.0	Students are adept at the arithmetic of complex numbers. They can use the trigonometric form of complex numbers and understand that a function of a complex variable can be viewed as a function of two real variables. They know the proof of DeMoivre's theorem.
	3.0	Students can give proofs of various formulas by using the technique of mathematical induction.
	4.0	Students know the statement of, and can apply, the fundamental theorem of algebra.
	5.0	Students are familiar with conic sections, both analytically and geometrically: 5.1 Students can take a quadratic equation in two variables; put it in standard form by completing the square and using rotations and translations, if necessary; determine what type of conic section the equation represents; and determine its geometric components (foci, asymptotes, and so forth). 5.2 Students can take a geometric description of a conic section—for example, the locus of points whose sum of its distances from (1, 0) and (-1, 0) is 6—and derive a quadratic equation representing it.
	6.0	Students find the roots and poles of a rational function and can graph the function and locate its asymptotes.
	7.0	Students demonstrate an understanding of functions and equations defined parametrically and can graph them.
	8.0	Students are familiar with the notion of the limit of a sequence and the limit of a function as the independent variable approaches a number or infinity. They determine whether certain sequences converge or diverge.

LINEAR ALGEBRA

	1.0	Students solve linear equations in any number of variables by using Gauss-Jordan elimination.
	2.0	Students interpret linear systems as coefficient matrices and the Gauss-Jordan method as row operations on the coefficient matrix.
	3.0	Students reduce rectangular matrices to row echelon form.
	4.0	Students perform addition on matrices and vectors.
	5.0	Students perform matrix multiplication and multiply vectors by matrices and by scalars.
	6.0	Students demonstrate an understanding that linear systems are inconsistent (have no solutions), have exactly one solution, or have infinitely many solutions.
	7.0	Students demonstrate an understanding of the geometric interpretation of vectors and vector addition (by means of parallelograms) in the plane and in three-dimensional space.
	8.0	Students interpret geometrically the solution sets of systems of equations. For example, the solution set of a single linear equation in two variables is interpreted as a line in the plane, and the solution set of a two-by-two system is interpreted as the intersection of a pair of lines in the plane.
	9.0	Students demonstrate an understanding of the notion of the inverse to a square matrix and apply that concept to solve systems of linear equations.
	10.0	Students compute the determinants of 2 X 2 and 3 X 3 matrices and are familiar with their geometric interpretations as the area and volume of the parallelepipeds spanned by the images under the matrices of the standard basis vectors in two-dimensional and three-dimensional spaces.
	11.0	Students know that a square matrix is invertible if, and only if, its determinant is nonzero. They can compute the inverse to 2 X 2 and 3 X 3 matrices using row reduction methods or Cramer's rule.
	12.0	Students compute the scalar (dot) product of two vectors in n-dimensional space and know that perpendicular vectors have zero dot product.

PROBABILITY AND STATISTICS

	1.0	Students know the definition of the notion of independent events and can use the rules for addition, multiplication, and complementation to solve for probabilities of particular events in finite sample spaces.
	2.0	Students know the definition of conditional probability and use it to solve for probabilities in finite sample spaces.
	3.0	Students demonstrate an understanding of the notion of discrete random variables by using them to solve for the probabilities of outcomes, such as the probability of the occurrence of five heads in 14 coin tosses.
	4.0	Students are familiar with the standard distributions (normal, binomial, and exponential) and can use them to solve for events in problems in which the distribution belongs to those families.
	5.0	Students determine the mean and the standard deviation of a normally distributed random variable.
	6.0	Students know the definitions of the mean, median, and mode of a distribution of data and can compute each in particular situations.
	7.0	Students compute the variance and the standard deviation of a distribution of data.
	8.0	Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.

ADVANCED PROBABILITY AND STATISTICS

	1.0	Students solve probability problems with finite sample spaces by using the rules for addition, multiplication, and complementation for probability distributions and understand the simplifications that arise with independent events.
	2.0	Students know the definition of *conditional probability* and use it to solve for probabilities in finite sample spaces.

MATHEMATICS CONTENT STANDARDS continued

GRADES EIGHT THROUGH TWELVE

ADVANCED PROBABILITY AND STATISTICS continued

	3.0	Students demonstrate an understanding of the notion of *discrete random variables* by using this concept to solve for the probabilities of outcomes, such as the probability of the occurrence of five or fewer heads in 14 coin tosses.
	4.0	Students understand the notion of a *continuous random variable* and can interpret the probability of an outcome as the area of a region under the graph of the probability density function associated with the random variable.
	5.0	Students know the definition of the *mean of a discrete random variable* and can determine the mean for a particular discrete random variable.
	6.0	Students know the definition of the *variance of a discrete random variable* and can determine the variance for a particular discrete random variable.
	7.0	Students demonstrate an understanding of the standard distributions (normal, binomial, and exponential) and can use the distributions to solve for events in problems in which the distribution belongs to those families.
	8.0	Students determine the mean and the standard deviation of a normally distributed random variable.
	9.0	Students know the central limit theorem and can use it to obtain approximations for probabilities in problems of finite sample spaces in which the probabilities are distributed binomially.
	10.0	Students know the definitions of the *mean*, *median*, and *mode of distribution* of data and can compute each of them in particular situations.
	11.0	Students compute the variance and the standard deviation of a distribution of data.
	12.0	Students find the line of best fit to a given distribution of data by using least squares regression.
	13.0	Students know what the *correlation coefficient of two variables* means and are familiar with the coefficient's properties.
	14.0	Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line graphs and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.
	15.0	Students are familiar with the notions of a statistic of a distribution of values, of the sampling distribution of a statistic, and of the variability of a statistic.
	16.0	Students know basic facts concerning the relation between the mean and the standard deviation of a sampling distribution and the mean and the standard deviation of the population distribution.
	17.0	Students determine confidence intervals for a simple random sample from a normal distribution of data and determine the sample size required for a desired margin of error.
	18.0	Students determine the *P*-value for a statistic for a simple random sample from a normal distribution.
	19.0	Students are familiar with the *chi*-square distribution and *chi*-square test and understand their uses.

CALCULUS

	1.0	Students demonstrate knowledge of both the formal definition and the graphical interpretation of limit of values of functions. This knowledge includes one-sided limits, infinite limits, and limits at infinity. Students know the definition of convergence and divergence of a function as the domain variable approaches either a number or infinity: 1.1 Students prove and use theorems evaluating the limits of sums, products, quotients, and composition of functions. 1.2 Students use graphical calculators to verify and estimate limits. 1.3 Students prove and use special limits, such as the limits of $(\sin(x))/x$ and $(1-\cos(x))/x$ as x tends to 0.
	2.0	Students demonstrate knowledge of both the formal definition and the graphical interpretation of continuity of a function.
	3.0	Students demonstrate an understanding and the application of the intermediate value theorem and the extreme value theorem.
	4.0	Students demonstrate an understanding of the formal definition of the derivative of a function at a point and the notion of differentiability: 4.1 Students demonstrate an understanding of the derivative of a function as the slope of the tangent line to the graph of the function. 4.2 Students demonstrate an understanding of the interpretation of the derivative as an instantaneous rate of change. Students can use derivatives to solve a variety of problems from physics, chemistry, economics, and so forth that involve the rate of change of a function. 4.3 Students understand the relation between differentiability and continuity. 4.4 Students derive derivative formulas and use them to find the derivatives of algebraic, trigonometric, inverse trigonometric, exponential, and logarithmic functions.
	5.0	Students know the chain rule and its proof and applications to the calculation of the derivative of a variety of composite functions.
	6.0	Students find the derivatives of parametrically defined functions and use implicit differentiation in a wide variety of problems in physics, chemistry, economics, and so forth.
	7.0	Students compute derivatives of higher orders.
	8.0	Students know and can apply Rolle's theorem, the mean value theorem, and L'Hôpital's rule.
	9.0	Students use differentiation to sketch, by hand, graphs of functions. They can identify maxima, minima, inflection points, and intervals in which the function is increasing and decreasing.
	10.0	Students know Newton's method for approximating the zeros of a function.
	11.0	Students use differentiation to solve optimization (maximum-minimum problems) in a variety of pure and applied contexts.
	12.0	Students use differentiation to solve related rate problems in a variety of pure and applied contexts.
	13.0	Students know the definition of the definite integral by using Riemann sums. They use this definition to approximate integrals.

MATHEMATICS CONTENT STANDARDS continued

GRADES EIGHT THROUGH TWELVE

CALCULUS continued

	14.0	Students apply the definition of the integral to model problems in physics, economics, and so forth, obtaining results in terms of integrals.
	15.0	Students demonstrate knowledge and proof of the fundamental theorem of calculus and use it to interpret integrals as antiderivatives.
	16.0	Students use definite integrals in problems involving area, velocity, acceleration, volume of a solid, area of a surface of revolution, length of a curve, and work.
	17.0	Students compute, by hand, the integrals of a wide variety of functions by using techniques of integration, such as substitution, integration by parts, and trigonometric substitution. They can also combine these techniques when appropriate.
	18.0	Students know the definitions and properties of inverse trigonometric functions and the expression of these functions as indefinite integrals.
	19.0	Students compute, by hand, the integrals of rational functions by combining the techniques in standard 17.0 with the algebraic techniques of partial fractions and completing the square.
	20.0	Students compute the integrals of trigonometric functions by using the techniques noted above.
	21.0	Students understand the algorithms involved in Simpson's rule and Newton's method. They use calculators or computers or both to approximate integrals numerically.
	22.0	Students understand improper integrals as limits of definite integrals.
	23.0	Students demonstrate an understanding of the definitions of convergence and divergence of sequences and series of real numbers. By using such tests as the comparison test, ratio test, and alternate series test, they can determine whether a series converges.
	24.0	Students understand and can compute the radius (interval) of the convergence of power series.
	25.0	Students differentiate and integrate the terms of a power series in order to form new series from known ones.
	26.0	Students calculate Taylor polynomials and Taylor series of basic functions, including the remainder term.
	27.0	Students know the techniques of solution of selected elementary differential equations and their applications to a wide variety of situations, including growth-and-decay problems.

SCIENCE CONTENT STANDARDS

GRADES NINE THROUGH TWELVE

PHYSICS

Motion and Forces

1. Newton's laws predict the motion of most objects. As a basis for understanding this concept:

	a.	Students know how to solve problems that involve constant speed and average speed.
	b.	Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
	c.	Students know how to apply the law $F = ma$ to solve one-dimensional motion problems that involve constant forces (Newton's second law).
	d.	Students know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).
	e.	Students know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.
	f.	Students know applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (e.g., Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).
	g.	Students know circular motion requires the application of a constant force directed toward the center of the circle.
	h.*	Students know Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.
	i.*	Students know how to solve two-dimensional trajectory problems.
	j.*	Students know how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.
	k.*	Students know how to solve two-dimensional problems involving balanced forces (statics).
	l.*	Students know how to solve problems in circular motion by using the formula for centripetal acceleration in the following form: $a = v^2/r$.
	m.*	Students know how to solve problems involving the forces between two electric charges at a distance (Coulomb's law) or the forces between two masses at a distance (universal gravitation).

Conservation of Energy and Momentum

2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept:

	a.	Students know how to calculate kinetic energy by using the formula $E = (1/2)mv^2$.
	b.	Students know how to calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) = mgh (h is the change in the elevation).
	c.	Students know how to solve problems involving conservation of energy in simple systems, such as falling objects.
	d.	Students know how to calculate momentum as the product mv.
	e.	Students know momentum is a separately conserved quantity different from energy.
	f.	Students know an unbalanced force on an object produces a change in its momentum.
	g.	Students know how to solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.
	h.*	Students know how to solve problems involving conservation of energy in simple systems with various sources of potential energy, such as capacitors and springs.

Heat and Thermodynamics

3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:

	a.	Students know heat flow and work are two forms of energy transfer between systems.
	b.	Students know that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.
	c.	Students know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.
	d.	Students know that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.
	e.	Students know that entropy is a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system.
	f.*	Students know the statement "Entropy tends to increase" is a law of statistical probability that governs all closed systems (second law of thermodynamics).
	g.*	Students know how to solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

PHYSICS continued

Waves

4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:

	a.	Students know waves carry energy from one place to another.
	b.	Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
	c.	Students know how to solve problems involving wavelength, frequency, and wave speed.
	d.	Students know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
	e.	Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8m/s (186,000 miles/second).
	f.	Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

Electric and Magnetic Phenomena

5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:

	a.	Students know how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.
	b.	Students know how to solve problems involving Ohm's law.
	c.	Students know any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = *IR* (potential difference) x *I* (current) = I^2R.
	d.	Students know the properties of transistors and the role of transistors in electric circuits.
	e.	Students know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.
	f.	Students know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
	g.	Students know how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.
	h.	Students know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.
	i.	Students know plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.
	j.*	Students know electric and magnetic fields contain energy and act as vector force fields.
	k.*	Students know the force on a charged particle in an electric field is qE, where E is the electric field at the position of the particle and q is the charge of the particle.
	l.*	Students know how to calculate the electric field resulting from a point charge.
	m.*	Students know static electric fields have as their source some arrangement of electric charges.
	n.*	Students know the magnitude of the force on a moving particle (with charge q) in a magnetic field is $qvB \sin(a)$, where a is the angle between v and B (v and B are the magnitudes of vectors v and B, respectively), and students use the right-hand rule to find the direction of this force.
	o.*	Students know how to apply the concepts of electrical and gravitational potential energy to solve problems involving conservation of energy.

CHEMISTRY

Atomic and Molecular Structure

1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:

	a.	Students know how to relate the position of an element in the periodic table to its atomic number and atomic mass.
	b.	Students know how to use the periodic table to identify metals, semimetals, non-metals, and halogens.
	c.	Students know how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.
	d.	Students know how to use the periodic table to determine the number of electrons available for bonding.
	e.	Students know the nucleus of the atom is much smaller than the atom yet contains most of its mass.
	f.*	Students know how to use the periodic table to identify the lanthanide, actinide, and transactinide elements and know that the transuranium elements were synthesized and identified in laboratory experiments through the use of nuclear accelerators.
	g.*	Students know how to relate the position of an element in the periodic table to its quantum electron configuration and to its reactivity with other elements in the table.
	h.*	Students know the experimental basis for Thomson's discovery of the electron, Rutherford's nuclear atom, Millikan's oil drop experiment, and Einstein's explanation of the photoelectric effect.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

CHEMISTRY continued

Atomic and Molecular Structure continued

1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:

	i.*	Students know the experimental basis for the development of the quantum theory of atomic structure and the historical importance of the Bohr model of the atom.
	j.*	Students know that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Planck's relationship ($E = hv$).

Chemical Bonds

2. Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:

	a.	Students know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.
	b.	Students know chemical bonds between atoms in molecules such as H_2, CH_4, NH_3, H_2CCH_2, N_2, Cl_2, and many large biological molecules are covalent.
	c.	Students know salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.
	d.	Students know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.
	e.	Students know how to draw Lewis dot structures.
	f.*	Students know how to predict the shape of simple molecules and their polarity from Lewis dot structures.
	g.*	Students know how electronegativity and ionization energy relate to bond formation.
	h.*	Students know how to identify solids and liquids held together by Van der Waals forces or hydrogen bonding and relate these forces to volatility and boiling/ melting point temperatures.

Conservation of Matter and Stoichiometry

3. The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:

	a.	Students know how to describe chemical reactions by writing balanced equations.
	b.	Students know the quantity *one mole* is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.
	c.	Students know one mole equals 6.02×10^{23} particles (atoms or molecules).
	d.	Students know how to determine the molar mass of a molecule from its chemical formula and a table of atomic masses and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.
	e.	Students know how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.
	f.*	Students know how to calculate percent yield in a chemical reaction.
	g.*	Students know how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.

Gases and Their Properties

4. The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:

	a.	Students know the random motion of molecules and their collisions with a surface create the observable pressure on that surface.
	b.	Students know the random motion of molecules explains the diffusion of gases.
	c.	Students know how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.
	d.	Students know the values and meanings of standard temperature and pressure (STP).
	e.	Students know how to convert between the Celsius and Kelvin temperature scales.
	f.	Students know there is no temperature lower than 0 Kelvin.
	g.*	Students know the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.
	h.*	Students know how to solve problems by using the ideal gas law in the form $PV = nRT$.
	i.*	Students know how to apply Dalton's law of partial pressures to describe the composition of gases and Graham's law to predict diffusion of gases.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

CHEMISTRY continued

Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:

	a.	Students know the observable properties of acids, bases, and salt solutions.
	b.	Students know acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
	c.	c. Students know strong acids and bases fully dissociate and weak acids and bases partially dissociate.
	d.	Students know how to use the pH scale to characterize acid and base solutions.
	e.*	Students know the Arrhenius, Brønsted-Lowry, and Lewis acid–base definitions.
	f.*	Students know how to calculate pH from the hydrogen-ion concentration.
	g.*	Students know buffers stabilize pH in acid–base reactions.

Solutions

6. Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:

	a.	Students know the definitions of *solute* and *solvent*.
	b.	Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
	c.	Students know temperature, pressure, and surface area affect the dissolving process.
	d.	Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.
	e.*	Students know the relationship between the molality of a solute in a solution and the solution's depressed freezing point or elevated boiling point.
	f.*	Students know how molecules in a solution are separated or purified by the methods of chromatography and distillation.

Chemical Thermodynamics

7. Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:

	a.	Students know how to describe temperature and heat flow in terms of the motion of molecules (or atoms).
	b.	Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.
	c.	Students know energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.
	d.	Students know how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.
	e.*	Students know how to apply Hess's law to calculate enthalpy change in a reaction.
	f.*	Students know how to use the Gibbs free energy equation to determine whether a reaction would be spontaneous.

Reaction Rates

8. Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules. As a basis for understanding this concept:

	a.	Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
	b.	Students know how reaction rates depend on such factors as concentration, temperature, and pressure.
	c.	Students know the role a catalyst plays in increasing the reaction rate.
	d.*	Students know the definition and role of activation energy in a chemical reaction.

Chemical Equilibrium

9. Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:

	a.	Students know how to use LeChatelier's principle to predict the effect of changes in concentration, temperature, and pressure.
	b.	Students know equilibrium is established when forward and reverse reaction rates are equal.
	c.*	Students know how to write and calculate an equilibrium constant expression for a reaction.

Organic Chemistry and Biochemistry

10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the bio-chemical basis of life. As a basis for understanding this concept:

	a.	Students know large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.
	b.	Students know the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules.
	c.	Students know amino acids are the building blocks of proteins.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

CHEMISTRY continued

Organic Chemistry and Biochemistry continued

10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the bio-chemical basis of life. As a basis for understanding this concept:

	d.*	Students know the system for naming the ten simplest linear hydrocarbons and isomers that contain single bonds, simple hydrocarbons with double and triple bonds, and simple molecules that contain a benzene ring.
	e.*	Students know how to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.
	f.*	Students know the R-group structure of amino acids and know how they combine to form the polypeptide backbone structure of proteins.

Nuclear Processes

11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:

	a.	Students know protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.
	b.	Students know the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by $E = mc^2$) is small but significant in nuclear reactions.
	c.	Students know some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
	d.	Students know the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.
	e.	Students know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.
	f.*	Students know how to calculate the amount of a radioactive substance remaining after an integral number of half lives have passed.
	g.*	Students know protons and neutrons have substructures and consist of particles called quarks.

BIOLOGY/LIFE SCIENCES

Cell Biology

1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:

	a.	Students know cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.
	b.	Students know enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings.
	c.	Students know how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.
	d.	Students know the central dogma of molecular biology outlines the flow of information from transcription of ribonucleic acid (RNA) in the nucleus to translation of proteins on ribosomes in the cytoplasm.
	e.	Students know the role of the endoplasmic reticulum and Golgi apparatus in the secretion of proteins.
	f.	Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.
	g.	Students know the role of the mitochondria in making stored chemical-bond energy available to cells by completing the breakdown of glucose to carbon dioxide.
	h.	Students know most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors.
	i.*	Students know how chemiosmotic gradients in the mitochondria and chloroplast store energy for ATP production.
	j.*	Students know how eukaryotic cells are given shape and internal organization by a cytoskeleton or cell wall or both.

Genetics

2. Mutation and sexual reproduction lead to genetic variation in a population. As a basis for understanding this concept:

	a.	Students know meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type.
	b.	Students know only certain cells in a multicellular organism undergo meiosis.
	c.	Students know how random chromosome segregation explains the probability that a particular allele will be in a gamete.
	d.	Students know new combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).
	e.	Students know why approximately half of an individual's DNA sequence comes from each parent.
	f.	Students know the role of chromosomes in determining an individual's sex.
	g.	Students know how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

BIOLOGY/LIFE SCIENCES continued

Genetics continued

3. A multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization. As a basis for understanding this concept:

	a.	Students know how to predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive).
	b.	Students know the genetic basis for Mendel's laws of segregation and independent assortment.
	c.*	Students know how to predict the probable mode of inheritance from a pedigree diagram showing phenotypes.
	d.*	Students know how to use data on frequency of recombination at meiosis to estimate genetic distances between loci and to interpret genetic maps of chromosomes.

4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept:

	a.	Students know the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA.
	b.	Students know how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.
	c.	Students know how mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.
	d.	Students know specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.
	e.	Students know proteins can differ from one another in the number and sequence of amino acids.
	f.*	Students know why proteins having different amino acid sequences typically have different shapes and chemical properties.

5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:

	a.	Students know the general structures and functions of DNA, RNA, and protein.
	b.	Students know how to apply base-pairing rules to explain precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA.
	c.	Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.
	d.*	Students know how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules.
	e.*	Students know how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.

Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:

	a.	Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
	b.	Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
	c.	Students know how fluctuations in population size in an ecosystem are deter-mined by the relative rates of birth, immigration, emigration, and death.
	d.	Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
	e.	Students know a vital part of an ecosystem is the stability of its producers and decomposers.
	f.	Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.
	g.*	Students know how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.

Evolution

7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:

	a.	Students know why natural selection acts on the phenotype rather than the genotype of an organism.
	b.	Students know why alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool.
	c.	Students know new mutations are constantly being generated in a gene pool.
	d.	Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

BIOLOGY/LIFE SCIENCES continued

Evolution continued

7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. As a basis for understanding this concept:

	e.*	Students know the conditions for Hardy-Weinberg equilibrium in a population and why these conditions are not likely to appear in nature.
	f.*	Students know how to solve the Hardy-Weinberg equation to predict the frequency of genotypes in a population, given the frequency of phenotypes.

8. Evolution is the result of genetic changes that occur in constantly changing environments. As a basis for understanding this concept:

	a.	Students know how natural selection determines the differential survival of groups of organisms.
	b.	Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.
	c.	Students know the effects of genetic drift on the diversity of organisms in a population.
	d.	Students know reproductive or geographic isolation affects speciation.
	e.	Students know how to analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction.
	f.*	Students know how to use comparative embryology, DNA or protein sequence comparisons, and other independent sources of data to create a branching diagram (cladogram) that shows probable evolutionary relationships.
	g.*	Students know how several independent molecular clocks, calibrated against each other and combined with evidence from the fossil record, can help to estimate how long ago various groups of organisms diverged evolutionarily from one another.

Physiology

9. As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept:

	a.	Students know how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.
	b.	Students know how the nervous system mediates communication between different parts of the body and the body's interactions with the environment.
	c.	Students know how feedback loops in the nervous and endocrine systems regulate conditions in the body.
	d.	Students know the functions of the nervous system and the role of neurons in transmitting electrochemical impulses.
	e.	Students know the roles of sensory neurons, interneurons, and motor neurons in sensation, thought, and response.
	f.*	Students know the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acid, and bile salts.
	g.*	Students know the homeostatic role of the kidneys in the removal of nitrogenous wastes and the role of the liver in blood detoxification and glucose balance.
	h.*	Students know the cellular and molecular basis of muscle contraction, including the roles of actin, myosin, Ca +2 , and ATP.
	i.*	Students know how hormones (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms.

10. Organisms have a variety of mechanisms to combat disease. As a basis for under-standing the human immune response:

	a.	Students know the role of the skin in providing nonspecific defenses against infection.
	b.	Students know the role of antibodies in the body's response to infection.
	c.	Students know how vaccination protects an individual from infectious diseases.
	d.	Students know there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections.
	e.	Students know why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign.
	f.*	Students know the roles of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

EARTH SCIENCES

Earth's Place in the Universe

1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:

	a.	Students know how the differences and similarities among the sun, the terrestrial planets, and the gas planets may have been established during the formation of the solar system.
	b.	Students know the evidence from Earth and moon rocks indicates that the solar system was formed from a nebular cloud of dust and gas approximately 4.6 billion years ago.
	c.	Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.
	d.	Students know the evidence indicating that the planets are much closer to Earth than the stars are.
	e.	Students know the Sun is a typical star and is powered by nuclear reactions, primarily the fusion of hydrogen to form helium.
	f.	Students know the evidence for the dramatic effects that asteroid impacts have had in shaping the surface of planets and their moons and in mass extinctions of life on Earth.
	g.*	Students know the evidence for the existence of planets orbiting other stars.

2. Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time. As a basis for understanding this concept:

	a.	Students know the solar system is located in an outer edge of the disc-shaped Milky Way galaxy, which spans 100,000 light years.
	b.	Students know galaxies are made of billions of stars and comprise most of the visible mass of the universe.
	c.	Students know the evidence indicating that all elements with an atomic number greater than that of lithium have been formed by nuclear fusion in stars.
	d.	Students know that stars differ in their life cycles and that visual, radio, and X-ray telescopes may be used to collect data that reveal those differences.
	e.*	Students know accelerators boost subatomic particles to energy levels that simulate conditions in the stars and in the early history of the universe before stars formed.
	f.*	Students know the evidence indicating that the color, brightness, and evolution of a star are determined by a balance between gravitational collapse and nuclear fusion.
	g.*	Students know how the red-shift from distant galaxies and the cosmic background radiation provide evidence for the "big bang" model that suggests that the universe has been expanding for 10 to 20 billion years.

Dynamic Earth Processes

3. Plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on Earth's surface. As the basis for understanding this concept:

	a.	Students know features of the ocean floor (magnetic patterns, age, and sea-floor topography) provide evidence of plate tectonics.
	b.	Students know the principal structures that form at the three different kinds of plate boundaries.
	c.	Students know how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
	d.	Students know why and how earthquakes occur and the scales used to measure their intensity and magnitude.
	e.	Students know there are two kinds of volcanoes: one kind with violent eruptions producing steep slopes and the other kind with voluminous lava flows producing gentle slopes.
	f.*	Students know the explanation for the location and properties of volcanoes that are due to hot spots and the explanation for those that are due to subduction.

Energy in the Earth System

4. Energy enters the Earth system primarily as solar radiation and eventually escapes as heat. As a basis for understanding this concept:

	a.	Students know the relative amount of incoming solar energy compared with Earth's internal energy and the energy used by society.
	b.	Students know the fate of incoming solar radiation in terms of reflection, absorption, and photosynthesis.
	c.	Students know the different atmospheric gases that absorb the Earth's thermal radiation and the mechanism and significance of the greenhouse effect.
	d.*	Students know the differing greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each.

5. Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. As a basis for understanding this concept:

	a.	Students know how differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.
	b.	Students know the relationship between the rotation of Earth and the circular motions of ocean currents and air in pressure centers.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

EARTH SCIENCES continued

Energy in the Earth System continued

5. Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. As a basis for understanding this concept:

	c.	Students know the origin and effects of temperature inversions.
	d.	Students know properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.
	e.	Students know rain forests and deserts on Earth are distributed in bands at specific latitudes.
	f.*	Students know the interaction of wind patterns, ocean currents, and mountain ranges results in the global pattern of latitudinal bands of rain forests and deserts.
	g.*	Students know features of the ENSO (El Niño southern oscillation) cycle in terms of sea-surface and air temperature variations across the Pacific and some climatic results of this cycle.

6. Climate is the long-term average of a region's weather and depends on many factors. As a basis for understanding this concept:

	a.	Students know weather (in the short run) and climate (in the long run) involve the transfer of energy into and out of the atmosphere.
	b.	Students know the effects on climate of latitude, elevation, topography, and proximity to large bodies of water and cold or warm ocean currents.
	c.	Students know how Earth's climate has changed over time, corresponding to changes in Earth's geography, atmospheric composition, and other factors, such as solar radiation and plate movement.
	d.*	Students know how computer models are used to predict the effects of the increase in greenhouse gases on climate for the planet as a whole and for specific regions.

Biogeochemical Cycles

7. Each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. As a basis for understanding this concept:

	a.	Students know the carbon cycle of photosynthesis and respiration and the nitrogen cycle.
	b.	Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.
	c.	Students know the movement of matter among reservoirs is driven by Earth's internal and external sources of energy.
	d.*	Students know the relative residence times and flow characteristics of carbon in and out of its different reservoirs.

Structure and Composition of the Atmosphere

8. Life has changed Earth's atmosphere, and changes in the atmosphere affect conditions for life. As a basis for understanding this concept:

	a.	Students know the thermal structure and chemical composition of the atmosphere.
	b.	Students know how the composition of Earth's atmosphere has evolved over geologic time and know the effect of outgassing, the variations of carbon dioxide concentration, and the origin of atmospheric oxygen.
	c.	Students know the location of the ozone layer in the upper atmosphere, its role in absorbing ultraviolet radiation, and the way in which this layer varies both naturally and in response to human activities.

California Geology

9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards. As a basis for understanding this concept:

	a.	Students know the resources of major economic importance in California and their relation to California's geology.
	b.	Students know the principal natural hazards in different California regions and the geologic basis of those hazards.
	c.	Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.
	d.*	Students know how to analyze published geologic hazard maps of California and know how to use the map's information to identify evidence of geologic events of the past and predict geologic changes in the future.

INVESTIGATION AND EXPERIMENTATION

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

	a.	Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
	b.	Identify and communicate sources of unavoidable experimental error.
	c.	Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
	d.	Formulate explanations by using logic and evidence.

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SCIENCE CONTENT STANDARDS continued

GRADES NINE THROUGH TWELVE

EARTH SCIENCES continued

INVESTIGATION AND EXPERIMENTATION continued

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

	e.	Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.
	f.	Distinguish between hypothesis and theory as scientific terms.
	g.	Recognize the usefulness and limitations of models and theories as scientific representations of reality.
	h.	Read and interpret topographic and geologic maps.
	i.	Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
	j.	Recognize the issues of statistical variability and the need for controlled tests.
	k.	Recognize the cumulative nature of scientific evidence.
	l.	Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
	m.	Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.
	n.	Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).

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HISTORY-SOCIAL SCIENCE CONTENT STANDARDS

GRADE NINE

The California State Board of Education has established grade nine History-Social Science as an elective year. There are no standards for grade nine.