7D

Information/Action

Professional Services Committee

Initial Accreditation and Program Review

Executive Summary: At its October meeting, the Commission reviewed two proposals submitted by institutions of higher education for subject matter program approval. The Commission requested that the reviewers of those programs be invited to the November/December meeting to discuss how in the review process that they were able to assure that the programs are aligned to K-12 student content standards.

Recommended Action: That the Commission act on the proposed Single Subject Matter Preparation Programs in Mathematics and Science: Physics.

Presenters: Helen Hawley, Consultant, and subject matter program reviewers.

Goal 1: Promote educational excellence through the preparation and certification of professional educators.

- Sustain high quality standards for the preparation of professional educators.
- Sustain high quality standards for the performance of credential candidates.

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Initial Accreditation and Program Review

Introduction

At its October meeting, the Commission reviewed two proposals submitted by institutions of higher education for subject matter program approval. The October agenda report included information about the two programs, a summary of the review procedures, a brief description of each program, a copy of the Subject Matter Requirements that are part of the program standards for each program, and a list of the program requirements for each program (Appendix A). The Commission requested that the reviewers of those programs be invited to the November/December meeting to discuss how they reviewed the responses to the Commission's program standards and how they were able to determine that each program met the subject matter requirements that are aligned to the K-12 student content standards, thus assuring that the program was aligned to the K-12 student content standards. The staff member overseeing the review process was also requested to be present.

Subject Matter Preparation Program Approval

Pursuant to Education Code Section 44311, each program was systematically reviewed by subject matter review panels in accordance with the Commission's adopted standards of quality and effectiveness for subject matter programs for the appropriate subject matter area. Panel members have judged that the following programs meet the Commission's *Standards of Quality and Effectiveness for Subject Matter Programs* and have judged that the curriculum in these programs addresses the K-12 Academic Content Standards by meeting the Commission's Subject Matter Requirements for the content area. Information about each program is presented in Appendix B. .

Based on the satisfactory review of the responses and evidence submitted, the following undergraduate subject matter programs are presented for consideration. The Commission has the option to grant or deny initial approval of these programs.

University of San Diego (Mathematics)

California State University, Chico (Science: Physics)

Granting initial program approval will allow these institutions to offer undergraduate programs that will satisfy the subject matter requirement for a single subject credential. Without approval, students enrolled in these programs will be required to pass a subject matter examination in order to demonstrate subject matter competency.

Appendix A

Subject Matter Requirements for Prospective Teachers of Mathematics[1]

Part I: Content Domains for Subject Matter Understanding and Skill in Mathematics

Domain 1. Algebra

Candidates demonstrate an understanding of the foundations of the algebra contained in the Mathematics Content Standards for California Public Schools (1997) as outlined in the Mathematics Framework for California Public Schools: Kindergarten Through Grade Twelve (1999) from an advanced standpoint. To ensure a rigorous view of algebra and its underlying structures, candidates have a deep conceptual knowledge. They are skilled at symbolic reasoning and use algebraic skills and concepts to model a variety of problem-solving situations. They understand the power of mathematical abstraction and symbolism.

1.1 Algebraic Structures

a. Know why the real and complex numbers are each a field, and that particular rings are not fields (e.g., integers, polynomial rings, matrix rings)
b. Apply basic properties of real and complex numbers in constructing mathematical arguments (e.g., if $a < b$ and $c < 0$, then $ac > bc$)
c. Know that the rational numbers and real numbers can be ordered and that the complex numbers cannot be ordered, but that any polynomial equation with real coefficients can be solved in the complex field

(Mathematics Content Standards for California Public Schools, Grade 6, Number Sense: 1.0, 2.0; Grade 7, Algebra and Functions: 1.0; Algebra I: 1.0, 3.0-7.0, 9.0-15.0, 24.0, 25.0; Geometry: 1.0, 17.0; Algebra II: 1.0-8.0, 11.0, 24.0, 25.0; Trigonometry: 17.0; Mathematical Analysis: 2.0; Linear Algebra: 9.0, 11.0)

1.2 Polynomial Equations and Inequalities

a. Know why graphs of linear inequalities are half planes and be able to apply this fact (e.g., linear programming)
b. Prove and use the following:
   - The Rational Root Theorem for polynomials with integer coefficients
   - The Factor Theorem
   - The Conjugate Roots Theorem for polynomial equations with real coefficients
   - The Quadratic Formula for real and complex quadratic polynomials
   - The Binomial Theorem
c. Analyze and solve polynomial equations with real coefficients using the Fundamental Theorem of Algebra

(Mathematics Content Standards for California Public Schools, Grade 7, Algebra and Functions: 2.0-4.0; Algebra I: 1.0, 2.0, 4.0-10.0, 12.0-15.0, 17.0-23.0; Algebra II: 2.0-11.0, 16.0, 17.0; Trigonometry: 17.0, 18.0; Mathematical Analysis: 4.0, 6.0)

1.3 Functions

a. Analyze and prove general properties of functions (i.e., domain and range, one-to-one, onto, inverses, composition, and differences between relations and functions)
b. Analyze properties of polynomial, rational, radical, and absolute value functions in a variety of ways (e.g., graphing, solving problems)
c. Analyze properties of exponential and logarithmic functions in a variety of ways (e.g., graphing, solving problems)

(Mathematics Content Standards for California Public Schools, Grade 6, Algebra and Functions: 1.0; Grade 7, Number Sense: 1.0, 2.0; Algebra and Functions: 3.0; Algebra I: 3.0-6.0, 10.0, 13.0, 15.0-18.0, 21.0-23.0; Algebra II: 1.0-4.0, 6.0-17.0, 24.0, 25.0; Trigonometry: 2.0, 4.0-8.0, 19.0; Mathematical Analysis: 6.0, 7.0; Calculus: 9.0)

1.4 Linear Algebra

a. Understand and apply the geometric interpretation and basic operations of vectors in two and three dimensions, including their scalar multiples and scalar (dot) and cross products
b. Prove the basic properties of vectors (e.g., perpendicular vectors have zero dot product)
c. Understand and apply the basic properties and operations of matrices and determinants (e.g., to determine the solvability of linear systems of equations)

(Mathematics Content Standards for California Public Schools, Algebra I: 9.0; Algebra II: 2.0; Mathematical Analysis: 1.0; Linear Algebra: 1.0-12.0)

Domain 2. Geometry

Candidates demonstrate an understanding of the foundations of the geometry contained in the Mathematics Content Standards for California Public Schools (1997) as outlined in the Mathematics Framework for California Public Schools: Kindergarten Through Grade Twelve (1999) from an advanced standpoint. To ensure a rigorous view of geometry and its underlying structures, candidates have a deep conceptual knowledge. They demonstrate an understanding of axiomatic systems and different forms of logical arguments. Candidates understand, apply, and prove theorems relating to a variety of topics in two- and three-dimensional geometry, including coordinate, synthetic, non-Euclidean, and transformational geometry.

2.1 Parallelism

a. Know the Parallel Postulate and its implications, and justify its equivalents (e.g., the Alternate Interior Angle Theorem, the angle sum of every triangle is 180 degrees)
b. Know that variants of the Parallel Postulate produce non-Euclidean geometries (e.g., spherical, hyperbolic)

(Mathematics Content Standards for California Public Schools, Algebra I: 8.0, 24.0; Geometry: 1.0-3.0, 7.0, 13.0)

2.2 Plane Euclidean Geometry

a. Prove theorems and solve problems involving similarity and congruence

b. Understand, apply, and justify properties of triangles (e.g., the Exterior Angle Theorem, concurrence theorems, trigonometric ratios, Triangle Inequality, Law of Sines, Law of Cosines, the Pythagorean Theorem and its converse)
c. Understand, apply, and justify properties of polygons and circles from an advanced standpoint (e.g., derive the area formulas for regular polygons and circles from the area of a triangle)
d. Justify and perform the classical constructions (e.g., angle bisector, perpendicular bisector, replicating shapes, regular n-gons for n equal to 3, 4, 5, 6, and 8)
e. Use techniques in coordinate geometry to prove geometric theorems

(Mathematics Content Standards for California Public Schools, Grade 6, Algebra and Functions: 2.0, 3.0; Measurement and Geometry: 2.0; Grade 7, Measurement and Geometry: 1.0-3.0; Algebra I: 8.0, 24.0; Geometry: 1.0-6.0, 8.0-16.0, 18.0-21.0; Algebra II: 16.0, 17.0; Trigonometry: 12.0-14.0, 18.0, 19.0; Mathematical Analysis: 5.0)

2.3 Three-Dimensional Geometry

a. Demonstrate an understanding of parallelism and perpendicularity of lines and planes in three dimensions
b. Understand, apply, and justify properties of three-dimensional objects from an advanced standpoint (e.g., derive the volume and surface area formulas for prisms, pyramids, cones, cylinders, and spheres)

(Mathematics Content Standards for California Public Schools, Grade 6, Measurement and Geometry: 1.0; Grade 7, Measurement and Geometry: 2.0; Algebra I: 24.0; Geometry: 2.0, 3.0, 12.0, 17.0; Mathematical Analysis: 5.0)

2.4 Transformational Geometry

a. Demonstrate an understanding of the basic properties of isometries in two- and three-dimensional space (e.g., rotation, translation, reflection)
b. Understand and prove the basic properties of dilations (e.g., similarity transformations or change of scale)

(Mathematics Content Standards for California Public Schools, Geometry: 11.0, 22.0)

Domain 3. Number Theory

Candidates demonstrate an understanding of the number theory and a command of the number sense contained in the Mathematics Content Standards for California Public Schools (1997) as outlined in the Mathematics Framework for California Public Schools: Kindergarten Through Grade Twelve (1999) from an advanced standpoint. To ensure a rigorous view of number theory and its underlying structures, candidates have a deep conceptual knowledge. They prove and use properties of natural numbers. They formulate conjectures about the natural numbers using inductive reasoning, and verify conjectures with proofs.

3.1 Natural Numbers

a. Prove and use basic properties of natural numbers (e.g., properties of divisibility)
b. Use the Principle of Mathematical Induction to prove results in number theory

c. Know and apply the Euclidean Algorithm
d. Apply the Fundamental Theorem of Arithmetic (e.g., find the greatest common factor and the least common multiple, show that every fraction is equivalent to a unique fraction where the numerator and denominator are relatively prime, prove that the square root of any number, not a perfect square number, is irrational)

(Mathematics Content Standards for California Public Schools, Grade 6, Number Sense: 2.0; Grade 7, Number Sense: 1.0; Algebra I: 1.0, 2.0, 12.0, 24.0, 25.0; Geometry: 1.0; Algebra II: 21.0, 23.0, 25.0; Mathematical Analysis: 3.0)

Domain 4. Probability and Statistics

Candidates demonstrate an understanding of the statistics and probability distributions for advanced placement statistics contained in the Mathematics Content Standards for California Public Schools (1997) as outlined in the Mathematics Framework for California Public Schools: Kindergarten Through Grade Twelve (1999) from an advanced standpoint. To ensure a rigorous view of probability and statistics and their underlying structures, candidates have a deep conceptual knowledge. They solve problems and make inferences using statistics and probability distributions.

4.1 Probability

a. Prove and apply basic principles of permutations and combinations
b. Illustrate finite probability using a variety of examples and models (e.g., the fundamental counting principles)
c. Use and explain the concept of conditional probability
d. Interpret the probability of an outcome
e. Use normal, binomial, and exponential distributions to solve and interpret probability problems

(Mathematics Content Standards for California Public Schools, Grade 6, Statistics, Data Analysis, and Probability: 3.0; Algebra II: 18.0-20.0; Probability and Statistics: 1.0-4.0; Advanced Probability and Statistics: 1.0-4.0, 7.0, 9.0, 17.0, 18.0)

4.2 Statistics

a. Compute and interpret the mean, median, and mode of both discrete and continuous distributions
b. Compute and interpret quartiles, range, variance, and standard deviation of both discrete and continuous distributions
c. Select and evaluate sampling methods appropriate to a task (e.g., random, systematic, cluster, convenience sampling) and display the results
d. Know the method of least squares and apply it to linear regression and correlation
e. Know and apply the chi-square test

(Mathematics Content Standards for California Public Schools, Grade 6, Statistics, Data Analysis, and Probability: 1.0, 2.0; Grade 7, Statistics, Data Analysis, and Probability: 1.0; Probability and Statistics: 5.0-7.0; Advanced Probability and Statistics: 4.0-6.0, 8.0, 10.0-13.0, 15.0-17.0, 19.0)

Domain 5. Calculus *(This domain does not apply to requirements for the Foundational-level Credential.)*

Candidates demonstrate an understanding of the trigonometry and calculus contained in the Mathematics Content Standards for California Public Schools (1997) as outlined in the Mathematics Framework for California Public Schools: Kindergarten Through Grade Twelve (1999) from an advanced standpoint. To ensure a rigorous view of trigonometry and calculus and their underlying structures, candidates have a deep conceptual knowledge. They apply the concepts of trigonometry and calculus to solving problems in real-world situations.

5.1 Trigonometry

a. Prove that the Pythagorean Theorem is equivalent to the trigonometric identity $\sin^2 x + \cos^2 x = 1$ and that this identity leads to $1 + \tan^2 x = \sec^2 x$ and $1 + \cot^2 x = \csc^2 x$
b. Prove the sine, cosine, and tangent sum formulas for all real values, and derive special applications of the sum formulas (e.g., double angle, half angle)
c. Analyze properties of trigonometric functions in a variety of ways (e.g., graphing and solving problems)
d. Know and apply the definitions and properties of inverse trigonometric functions (i.e., arcsin, arccos, and arctan)
e. Understand and apply polar representations of complex numbers (e.g., DeMoivre's Theorem)

(Mathematics Content Standards for California Public Schools, Algebra I: 24.0; Geometry: 3.0, 14.0, 18.0, 19.0; Algebra II: 24.0, 25.0; Trigonometry: 1.0-6.0, 8.0-11.0, 19.0; Mathematical Analysis: 1.0, 2.0; Calculus: 18.0, 20.0)

5.2 Limits and Continuity

a. Derive basic properties of limits and continuity, including the Sum, Difference, Product, Constant Multiple, and Quotient Rules, using the formal definition of a limit
b. Show that a polynomial function is continuous at a point
c. Know and apply the Intermediate Value Theorem, using the geometric implications of continuity

(Mathematics Content Standards for California Public Schools, Algebra I: 24.0; Geometry: 3.0; Algebra II: 1.0, 15.0; Mathematical Analysis: 8.0; Calculus: 1.0-4.0)

5.3 Derivatives and Applications

a. Derive the rules of differentiation for polynomial, trigonometric, and logarithmic functions using the formal definition of derivative
b. Interpret the concept of derivative geometrically, numerically, and analytically (i.e., slope of the tangent, limit of difference quotients, extrema, Newton's method, and instantaneous rate of change)
c. Interpret both continuous and differentiable functions geometrically and analytically and apply Rolle's Theorem, the Mean Value Theorem, and L'Hopital's rule
d. Use the derivative to solve rectilinear motion, related rate, and optimization problems
e. Use the derivative to analyze functions and planar curves (e.g., maxima, minima, inflection points, concavity)

f. Solve separable first-order differential equations and apply them to growth and decay problems

(Mathematics Content Standards for California Public Schools, Algebra I: 5.0-8.0, 10.0, 11.0, 13.0, 21.0, 23.0; Geometry: 3.0; Algebra II: 1.0, 9.0, 10.0, 12.0, 15.0; Trigonometry: 7.0, 15.0-19.0; Mathematical Analysis: 5.0, 7.0; Calculus: 1.0, 4.0-12.0, 27.0)

5.4 Integrals and Applications

a. Derive definite integrals of standard algebraic functions using the formal definition of integral
b. Interpret the concept of a definite integral geometrically, numerically, and analytically (e.g., limit of Riemann sums)
c. Prove the Fundamental Theorem of Calculus, and use it to interpret definite integrals as antiderivatives
d. Apply the concept of integrals to compute the length of curves and the areas and volumes of geometric figures

(Mathematics Content Standards for California Public Schools, Algebra I: 24.0; Geometry: 9.0; Calculus: 13.0-23.0)

5.5 Sequences and Series

a. Derive and apply the formulas for the sums of finite arithmetic series and finite and infinite geometric series (e.g., express repeating decimals as a rational number)
b. Determine convergence of a given sequence or series using standard techniques (e.g., Ratio, Comparison, Integral Tests)
c. Calculate Taylor series and Taylor polynomials of basic functions

(Mathematics Content Standards for California Public Schools, Algebra I: 24.0, 25.0; Algebra II: 21.0-23.0; Mathematical Analysis: 8.0; Calculus: 23.0-26.0)

Domain 6. History of Mathematics ***(This domain does not apply to requirements for the Foundational-level Credential.)***

Candidates understand the chronological and topical development of mathematics and the contributions of historical figures of various times and cultures. Candidates know important mathematical discoveries and their impact on human society and thought. These discoveries form a historical context for the content contained in the Mathematics Content Standards for California Public Schools (1997) as outlined in the Mathematics Framework for California Public Schools: Kindergarten Through Grade Twelve (1999; e.g., numeration systems, algebra, geometry, calculus).

6.1 Chronological and Topical Development of Mathematics

a. Demonstrate understanding of the development of mathematics, its cultural connections, and its contributions to society
b. Demonstrate understanding of the historical development of mathematics, including the contributions of diverse populations as determined by race, ethnicity, culture, geography, and gender

Part II: Subject Matter Skills and Abilities Applicable to the Content Domains in Mathematics

(All elements of Part II apply to both the Single Subject Credential in Mathematics and the Single Subject Credential in Foundational Mathematics.)

Candidates for Single Subject Teaching Credentials in mathematics use inductive and deductive reasoning to develop, analyze, draw conclusions, and validate conjectures and arguments. As they reason, they use counterexamples, construct proofs using contradictions, and create multiple representations of the same concept. They know the interconnections among mathematical ideas, and use techniques and concepts from different domains and sub-domains to model the same problem. They explain mathematical interconnections with other disciplines. They are able to communicate their mathematical thinking clearly and coherently to others, orally, graphically, and in writing, through the use of precise language and symbols.

Candidates solve routine and complex problems by drawing from a variety of strategies while demonstrating an attitude of persistence and reflection in their approaches. They analyze problems through pattern recognition and the use of analogies. They formulate and prove conjectures, and test conclusions for reasonableness and accuracy. They use counterexamples to disprove conjectures.

Candidates select and use different representational systems (e.g., coordinates, graphs). They understand the usefulness of transformations and symmetry to help analyze and simplify problems. They make mathematical models to analyze mathematical structures in real contexts. They use spatial reasoning to model and solve problems that cross disciplines.

(Mathematics Content Standards for California Public Schools, Grade 6, Mathematical Reasoning: 1.0-3.0; Grade 7, Mathematical Reasoning: 1.0-3.0)

Subject Matter Requirements for Prospective Teachers General Science

Part I: Content Domains for Subject Matter Understanding and Skill in General Science

Domain 1. Astronomy

Candidates demonstrate an understanding of the foundations of the astronomy contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of astronomy and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that knowledge of the structure and composition of the universe can be learned from studying stars and galaxies and their evolution. They recognize that objects in the sky move in regular and predictable patterns. Candidates explain how and why the moon's appearance changes during the four-week lunar cycle. They understand how telescopes magnify the appearance of distant objects in the sky, including the moon and the planets. They realize that the solar system consists of planets and other bodies that orbit the sun in predictable paths.

1.1 Astronomy

a. Describe the chemical composition and physical structure of the universe
b. Describe the structure of the solar system and its place in the Milky Way galaxy
c. Distinguish between stars and planets
d. Recognize that stars vary in color, size, and luminosity
e. Describe a simple model of how fusion in stars produces heavier elements and results in the production of energy, including light
f. Describe the regular and predictable patterns of stars and planets in time and location
g. Explain and predict changes in the moon's appearance (phases)
h. Describe the use of astronomical instruments in collecting data, and use astronomical units and light years to describe distances

(Science Content Standards for California Public Schools, Grades 3:4a-e; Grade 5: 5a-c; Grade 6: 7a; Grade 7: 6d, 7a; Grade 8:4a-e; Grades 9-12, Earth Sciences: 1a, 1e, 1g, 2a, 2c, 2e-f)

Domain 2. Dynamic Processes of the Earth (Geodynamics)

Candidates demonstrate an understanding of the foundations of the geodynamics contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of geodynamics and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that Earth's features can be explained by a variety of dynamic processes that have occurred in the past and continue to occur. They understand that plate tectonics account for most of the important features of Earth's surface and major geologic events. Candidates explain how surficial processes and agents such as waves, wind, water, and

ice are slowly modifying Earth's land surface. They understand how weathering, transport, and deposition of sediment are related to this reshaping. Candidates are familiar with evidence from rocks that allows us to understand geologic history and the evolution of life on Earth. They can use observed properties of rocks and minerals to determine their processes of formation. Candidates understand that most of the energy on the Earth comes from the sun. They know that energy from the sun heats Earth unevenly, causing air movements that result in changing weather patterns. They use their understanding of heat to explain the many phenomena on Earth's surface that are affected by the transfer of energy through radiation and convection.

2.1 Tectonic Processes and Features

a. Diagram the features that provide evidence for plate tectonics
b. Summarize the thermal processes driving plate movement
c. Explain how density and buoyancy are related to plate tectonics
d. Describe types of plate boundaries
e. Relate the causes of volcanoes, earthquakes, and earth resources to tectonic processes
f. Summarize earthquake processes in terms of epicenter, focal mechanism, distance, and materials, and the role various factors play in the amount of damage caused by an earthquake

(Science Content Standards for California Public Schools, Grade 6: 1a-g; Grade 8: 4a-e; Grades 9-12, Earth Sciences: 1e, 1g, 2c, 3b, 3d)

2.2 Rock Formation

a. Diagram and explain the rock cycle
b. Describe relative and absolute dating techniques, including how half-lives are used in radiometric dating

(Science Content Standards for California Public Schools, Grade 4: 4a; Grade 7: 3c, 4a–e; Grades 9-12, Chemistry: 11f)

2.3 Shaping Earth's Surface: Surficial Processes and Features

a. Describe the dynamic processes of erosion, deposition, and transport
b. Describe coastal processes including beach erosion and natural hazards
c. Describe the effects of natural hazards, including earthquakes, volcanic eruptions, landslides, and floods, on natural and human-made habitats and environmental and human responses to those events

(Science Content Standards for California Public Schools, Grade 4: 5c; Grade 6: 1e, 1f, 2a–d)

2.4 Energy in the Earth System

a. Diagram the water cycle and describe interrelationships of surface and sub-surface reservoirs
b. Explain daily and seasonal changes in the sky (i.e., the sun's position and the intensity and duration of sunlight)
c. Analyze the uneven heating of Earth by the sun
d. Discuss the effects of air movements on weather

e. Describe the energy transfer processes of convection, conduction, and radiation in relation to the atmosphere/ocean and Earth's interior structure
f. Interpret weather maps to predict weather patterns

(Science Content Standards for California Public Schools, Grade 3: 4e; Grade 5: 3a-d, 4a-e; Grade 6: 4a-e; Grades 9-12, Earth Sciences: 5a-b)

Domain 3. Earth Resources

Candidates demonstrate an understanding of the Earth resources contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of Earth resources and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates know there are many different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable. They realize that sources of energy and materials differ in amounts, distribution, usefulness, and the time required for their formation. Candidates understand that the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process. They know the natural origin of the materials used to make common objects.

3.1 Earth Resources

a. Describe a variety of energy resources, including fossil fuels, nuclear fuels, solar, and biomass
b. Recognize earth materials as resources (e.g., rocks, minerals, soils, and water)
c. Identify resources as renewable vs. nonrenewable
d. Compare extraction and recycling in relation to energy, cost, and demand
e. Explain sustainable uses of resources with respect to utility, cost, human population, and environmental consequences

(Science Content Standards for California Public Schools, Grade 2: 3e; Grade 6: 6a-c; Grades 9-12, Earth Sciences: 9a, 9c)

Domain 4. Ecology

Candidates demonstrate an understanding of the foundations of the ecology contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of ecology and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand how organisms in ecosystems exchange energy and nutrients among themselves and with the environment. They can identify factors that affect organisms within an ecosystem, including natural hazards and human activity.

4.1 Ecology

a. Explain energy flow and nutrient cycling through ecosystems (e.g., food chain, food web)
b. Explain matter transfer (e.g., biogeochemical cycles) in ecosystems
c. Distinguish between abiotic and biotic factors in an ecosystem
d. Compare the roles of photosynthesis and respiration in an ecosystem
e. Describe interrelationships within and among ecosystems (e.g., predator/prey)
f. Identify and explain factors that affect population types and size (e.g., competition for resources, niche, habitats, species and population interactions, abiotic factors)

(Science Content Standards for California Public Schools, Grade 4: 2a-c, 3a-c; Grade 5: 2f-g; Grade 6: 5a-e)

Domain 5. Genetics and Evolution

Candidates demonstrate an understanding of the foundations of the genetics and evolution contained in the Science Content Standards for California Public Schools Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of genetics and evolution and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that a typical cell of any organism contains genetic instructions that specify its traits. They can explain how biological evolution accounts for the diversity of species that developed through gradual processes over many generations. Candidates can describe evidence used to explain the evolution of life on Earth.

5.1 Genetics and Evolution

a. Explain the inheritance of traits which are determined by one or more genes, including dominance, recessiveness, sex linkage, phenotypes, genotypes, and incomplete dominance
b. Solve problems that illustrate monohybrid and dihybrid crosses
c. Compare sexual and asexual reproduction
d. Explain how the coding of DNA (deoxyribonucleic acid) controls the expression of traits by genes
e. Define mutations and explain their causes
f. Explain the process of DNA replication
g. Describe evidence, past and present, that supports the theory of evolution, including diagramming relationships that demonstrate shared characteristics of fossil and living organisms
h. Explain the theory of natural selection, including adaptation, speciation, and extinction
i. List major events that affected the evolution of life on Earth (e.g., climate changes, asteroid impacts)

(Science Content Standards for California Public Schools, Grade 7: 2a-e, 3a-e; Grades 9-12, Biology/Life Sciences: 4c, 7c, 8a)

Domain 6. Molecular Biology and Biochemistry

Candidates demonstrate an understanding of the foundations of the molecular biology and biochemistry contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of molecular biology and biochemistry and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand and apply the principles of chemistry that underlie the functioning of biological systems. They describe the properties of biochemical compounds that make them essential to life.

6.1 Biology and Biochemistry

a. Demonstrate understanding that a small subset of elements (C, H, O, N, P, S) makes up most of the chemical compounds in living organisms by combining in many ways

b. Recognize and differentiate the structure and function of molecules in living organisms, including carbohydrates, lipids, proteins, and nucleic acids
c. Describe the process of protein synthesis, including transcription and translation
d. Compare anaerobic and aerobic respiration
e. Describe the process of photosynthesis

(Science Content Standards for California Public Schools, Grade 5: 2f-g; Grade 6: 5a; Grade 8: 6b-c; Grades 9-12, Biology/Life Sciences: 1d, 1f, 1g, 1h, 4a, Chemistry: 10c)

Domain 7. Cell and Organismal Biology

Candidates demonstrate an understanding of the foundations of the cell and organismal biology contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of cell and organismal biology and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that all living organisms are composed of cells and explain important cellular processes. They describe and give examples of how the anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. Candidates demonstrate understanding of physical principles that underlie biological structures and functions. They apply these principles to important biological systems.

7.1 Cell and Organismal Biology

a. Describe organelles and explain their function in the cell
b. Relate the structure of organelles and cells to their functions
c. Identify and contrast animal and plant cells
d. Explain the conversion, flow, and storage of energy of the cell
e. Identify the function and explain the importance of mitosis and meiosis as processes of cellular and organismal reproduction
f. Compare single-celled and multicellular organisms, noting the role of cell differentiation in the development of multicellular organisms

g. Describe the levels of organization (e.g., cells, tissues, organs, systems, organisms) in plants and animals
h. Describe the structures and functions of human body systems, including, but not limited to, the skeletal, reproductive, nervous, and circulatory systems
i. Explain the major structures and their functions in vascular and nonvascular plants
j. Describe the life processes of various plant groups, including, but not limited to, reproduction, photosynthesis, respiration, and transpiration
k. Explain the reproductive processes in flowering plants

(Science Content Standards for California Public Schools, Grade 3: 1b, 1c; Grade 5: 2a, 2e; Grade 7: 1a-f, 5a-g, 6d, 6h-j)

Domain 8. Waves

Candidates demonstrate an understanding of the foundations of waves as contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of waves and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that all waves have a common set of characteristic properties. They apply their knowledge of these properties to describe and predict the behavior of waves, including light waves, sound waves, and seismic waves. Candidates apply the simple principles of optics to explain how various lenses work.

8.1 Waves

a. Compare the characteristics of sound, light, and seismic waves (e.g., transverse/longitudinal, travel through various media, relative speed)
b. Explain that energy is transferred by waves without mass transfer and provide examples
c. Explain how lenses are used in simple optical systems, including the camera, telescope, microscope, and the eye
d. Explain and apply the laws of reflection and refraction
e. Compare transmission, reflection, and absorption of light in matter

(Science Content Standards for California Public Schools, Grade 3: 1d, 2a-d, 4c; Grade 6: 3a; Grade 7: 6a, 6c-g; Grades 9-12, Physics: 4a-b, 4d, 4f)

Domain 9. Forces and Motion

Candidates demonstrate an understanding of the foundations of forces and motion as contained in the Science Content Standards for California Public Schools Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of forces and motion and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates describe the motion of an object and understand the relationships among its velocity, speed, distance, time, and acceleration. They understand the relationship among force, mass, and acceleration. Candidates use Newton's laws to predict the motion of objects.

9.1 **Forces and Motion**

a. Discuss and apply Newton's laws (i.e., first, second, third, and law of universal gravitation)
b. Define pressure and relate it to fluid flow and buoyancy (e.g., heart valves, atmospheric pressure)
c. Describe the relationships among position, distance, displacement, speed, velocity, acceleration, and time, and perform simple calculations using these variables for both linear and circular motion
d. Identify the separate forces that act on a body (e.g., gravity, pressure, tension/compression, normal force, friction) and describe the net force on the body
e. Construct and analyze simple vector and graphical representations of motion and forces (e.g., distance, speed, time)
f. Identify fundamental forces, including gravity, nuclear forces, and electromagnetic forces (magnetic and electric), and explain their roles in nature, such as the role of gravity in maintaining the structure of the universe
g. Explain and calculate mechanical advantages for levers, pulleys, and inclined planes

(Science Content Standards for California Public Schools, Grade 7: 6h-j; Grade 8: 1a-f, 2a-g)

Domain 10. Electricity and Magnetism

Candidates demonstrate an understanding of the foundations of the electricity and magnetism contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of electricity and magnetism and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand that electric and magnetic phenomena are related. They use knowledge of electricity and magnetism to explain many practical applications.

10.1 Electricity and Magnetism

a. Describe and provide examples of electrostatic and magnetostatic phenomena
b. Predict charges or poles based on attraction/repulsion observations
c. Build a simple compass and use it to determine direction of magnetic fields, including the Earth's magnetic field
d. Relate electric currents to magnetic fields and describe the application of these relationships, such as in electromagnets, electric current generators, motors, and transformers
e. Design and interpret simple series and parallel circuits
f. Define and calculate power, voltage differences, current, and resistance in simple circuits

(Science Content Standards for California Public Schools, Grade 4: 1a-g; Grade 9-12, Physics: 5a-c)

Domain 11. Heat Transfer and Thermodynamics

Candidates demonstrate an understanding of the foundations of heat transfer and thermodynamics as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for

California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of heat transfer and thermodynamics and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates explain how heat flows in a predictable manner. They understand that energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. Candidates apply their knowledge to explain how many phenomena on Earth's surface are affected by the transfer of energy through radiation and convection currents.

11.1 Heat Transfer and Thermodynamics

a. Know the principle of conservation of energy and apply it to energy transfers
b. Discuss how the transfer of energy as heat is related to changes in temperature
c. Diagram the direction of heat flow in a system
d. Describe the methods of heat transfer by conduction, convection, and radiation, and provide examples for each
e. Explain how chemical energy in fuel is transformed to heat
f. Design and explain experiments to induce a physical change such as freezing, melting, or boiling
g. Distinguish between physical and chemical changes and provide examples of each

(Science Content Standards for California Public Schools, Grade 6: 3a-d, 4d; Grade 8: 3b, 3d-e, 5c-d; Grade 9-12, Physics: 3a-c, Chemistry: 7a-c)

Domain 12. Structure and Properties of Matter

Candidates demonstrate an understanding of the structure and properties of matter contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of matter and its underlying structures, candidates have a deep conceptual knowledge of the content area. Candidates know that more than 100 elements of matter exist, each with distinct properties and a distinct atomic structure. They describe both macroscopic and microscopic properties of matter including intermolecular and intramolecular forces. They know that the organization of the periodic table is based on the properties of the elements and reflects the structure of atoms. Candidates understand how the periodic table is constructed and the periodic trends in chemical and physical properties that can be seen in the table. They recognize chemical reactions as processes that involve the rearrangement of electrons to break and form bonds with different atomic partners. Candidates demonstrate understanding of the principles of chemistry that underlie the functioning of biological systems.

12.1 Structure and Properties of Matter

a. Identify, describe, and diagram the basic components within an atom (i.e., proton, neutron, and electron)
b. Know that isotopes of any element have different numbers of neutrons but the same number of protons, and that some isotopes are radioactive
c. Differentiate between atoms, molecules, elements, and compounds
d. Compare and contrast states of matter and describe the role energy plays in the conversion from one state to another
e. Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity

f. Recognize that all chemical substances are characterized by a unique set of physical properties
g. Define and calculate density, and predict whether an object will sink or float in a fluid
h. Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules
i. Explain and apply principles of conservation of matter to chemical reactions, including balancing chemical equations
j. Distinguish among acidic, basic, and neutral solutions by their observable properties
k. Describe the construction and organization of the periodic table
l. Based on position in the periodic table, predict which elements have characteristics of metals, semi-metals, non-metals, and inert gases
m. Explain chemical reactivity using position on the periodic table
n. Predict and explain chemical bonding using elements' positions in the periodic table
o. Recognize that inorganic and organic compounds (e.g., water, salt, carbohydrates, lipids, proteins, nucleic acids) are essential to processes within living systems
p. Explain the central role of carbon in living system chemistry

(Science Content Standards for California Public Schools, Grade 8: 3a-c, 5a-e, 6a, 6c, 7a-c, 8a-d; Grades 9-12, Chemistry: 7b, 11c)

Physics Subject Matter Requirements

Part I: Content Domains for Subject Matter Understanding and Skill in Physics

Domain 1. Motion and Forces

Candidates demonstrate an understanding of the foundations of motion and forces as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of motion and forces and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of motion and the relationship of force to motion. Candidates use analytical, numerical, and graphical methods in problem-solving.

1.1 Motion and Forces

a. Solve problems using Newton's Second Law (e.g., problems involving time, velocity, and space-dependent forces)
b. Construct appropriate free-body diagrams of many-body problems (e.g., two or more coupled masses)
c. Solve periodic motion problems
d. Solve 2-dimensional problems involving vector analysis of motion and forces, including projectile motion, uniform circular motion, and statics
e. Generate and understand functional relationships of graphs showing distance, velocity, and acceleration versus time
f. Recognize relationships among variables for linear motion and rotational motion
g. Solve problems involving linear and rotational motion in term of forces and torques

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 1a-m)

Domain 2. Conservation of Energy and Momentum

Candidates demonstrate an understanding of the conservation of energy and momentum contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of conservation of energy and momentum and of their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate an understanding of the principles of conservation of energy and momentum. They apply this understanding to predict and describe the movement of objects.

2.1 Conservation of Energy and Momentum

a. Use conservation of energy to characterize kinetic-potential energy systems such as oscillating systems (pendula and springs), projectile motion, and roller coasters
b. Analyze elastic and inelastic collisions and solve for unknown values
c. Solve problems involving linear and rotational motion in terms of conservation of momentum and energy

d. Recognize relationships between energy/momentum conservation principles and Newton's Laws
e. Examine the impact of friction on conservation principles
f. Interpret force-versus-time and force-versus-distance graphs to find, for example, work done or impulse on a system

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 2a-h)

Domain 3. Heat and Thermodynamics

Candidates demonstrate an understanding of the foundations of heat and thermodynamics as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of heat and thermodynamics and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates demonstrate understanding of the laws of thermodynamics and the thermodynamic properties of materials.

3.1 Heat and Thermodynamics

a. Solve problems involving the laws of thermodynamics using the relationships among work, heat flow, energy, and entropy
b. Define and correctly apply thermodynamic properties of materials such as specific heat (heat capacity), heats of fusion, heat of vaporization, thermal conductivity, and thermal expansion to solve problems
c. Solve problems for ideal gas systems
d. Solve problems involving cyclic processes, including calculations of work done, heat gain/loss, , and entropy change
e. Interpret graphs showing phase changes and graphs of cyclic processes
f. Describe a plasma, state its characteristic properties, and contrast it with an ideal gas

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 3a-g)

Domain 4. Waves

Candidates demonstrate an understanding of the foundations of waves as contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) and outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of waves and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates can describe waves and their characteristic properties and understand that these properties do not depend on the type of wave. They use their knowledge of waves and wave properties to predict wave behavior under various conditions. Candidates are familiar with the electromagnetic spectrum.

4.1 Waves and Their Characteristic Properties

a. Relate wave propagation to properties of materials (e.g., predict wave speed from density and tension)

b. Describe, distinguish, and solve both conceptual and numerical problems involving interference, diffraction, refraction, reflection, Doppler effect, polarization, dispersion, and scattering

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 4a-f)

Domain 5. Electromagnetism

Candidates demonstrate an understanding of the foundations of electromagnetism contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of electromagnetism and its underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates understand the relationship between electric and magnetic phenomena and can apply their knowledge to real-life examples. They can solve calculus-based problems using the quantitative and vector relationships among charges, currents, forces, and fields.

5.1 Electric and Magnetic Phenomena

a. Analyze electric and magnetic forces, charges, and fields using Coulomb's law, the Lorentz force, and the right-hand rule
b. Apply energy principles to analyze problems in electricity, magnetism, and circuit theory involving capacitors, resistors, and inductors
c. Calculate power, voltage changes, current, and resistance in multiloop circuits involving capacitors, resistors, and inductors
d. Interpret and design mixed series and parallel circuits involving capacitors, resistors, and inductors
e. Solve problems involving the relationships between electric and magnetic phenomena
f. Explain properties of transistors, diodes, and semiconductors

(Science Content Standards for California Public Schools, Grades 9-12, Physics: 5a-o)

Domain 6. Quantum Mechanics and the Standard Model of Particles

Candidates demonstrate an understanding of the foundations of quantum mechanics and the standard model of particles contained in the Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve (1998) as outlined in the Science Framework for California Public Schools: Kindergarten Through Grade Twelve (2002) from an advanced standpoint. To ensure a rigorous view of quantum mechanics and the standard model of particles and their underlying structures, candidates have a deep conceptual knowledge of the subject matter. Candidates are familiar with the standard model of particles and the four fundamental forces of nature. They recognize the assumptions and principles of early quantum mechanics.

6.1 Quantum Mechanics and the Standard Model

a. Distinguish the four fundamental forces of nature, describe their ranges, and identify their force carriers
b. Evaluate the assumptions and relevance of the Bohr model of the atom

(Science Content Standards for California Public Schools, Grades 9-12, Chemistry: 1i)

Appendix B

University of San Diego

Mathematics Subject Matter Preparation Program Requirements

The coursework requirements listed for this program have been found by reviewers to meet the Commission's requirements and the content of the program meets the Commission's standards and subject matter requirements. A matrix chart is also included illustrate for Commissioners where the domains of the Mathematics Subject Matter Requirements are addressed in the program. In the course of the program review, the reviewers examine supporting evidence to determine how and to what extent the domains are covered in the program.

Information from Standard 1 – (The following information was excerpted from the institutional response to Program Standard 1 that asks the institution to describe how its program philosophy and design is related to the Commission's standards and how it reflects and builds on the State-adopted academic content standards for K-12 students and the curriculum frameworks for California public schools.) The development of the Mathematics Single Subject Credential Program at USD was guided by the university's mission statement, the goals of the Department of Mathematics and Computer Science for the mathematics major, and the department's statement on teacher preparation, with attention to the Mathematics Content Standards for California Public Schools, K-12 and the Mathematics Framework for California Public Schools. The required mathematics content courses in the program have been selected so that students take academic courses that cover the content in all of the mathematics subject matter domains commonly taught in K-12 schools: algebra, geometry, number theory, probability and statistics, calculus and the history of mathematics. The required and elective extended studies courses contribute to the students' understanding of the different branches of mathematics, related disciplines and mathematics education. The newly developed capstone course, Math 405 (Advanced Perspectives on Secondary School Mathematics) has been designed to increase students' understanding of the connections between the branches of mathematics and the connections between higher mathematics and secondary school mathematics.

Course work includes concepts and problem solving within mathematical domains, such as calculus and geometry, as well as the role of mathematical reasoning and proof and the mathematical applications in the development of mathematics and its role in society. The program recognizes that future teachers of mathematics need to develop a profound understanding of secondary school mathematics and be able to understand how mathematics on that level is related to higher and lower level mathematics. The program develops their ability to communicate that understanding and to use appropriate technology.

Units Required in the Program The subject matter preparation program in mathematics at the University of San Diego consists of a minimum of 38 semester units of core required courses and 16 semester units of extended studies courses.

Core Requirements The core requirements are listed below, and their relationship to the commonly taught subjects is shown in Table 1 on the next page:

Math 115 (College Algebra) or math placement exam	0-3 units
Math 120 (Introduction to Probability and Statistics)	3 units
Math 150 (Calculus I)	4 units
Math 151 (Calculus II)	4 units
Math 160 (Logic for Mathematics and Computer Science)	3 units
Math 250 (Calculus III)	4 units
Math 320 (Linear Algebra)	3 units
Math 325W (History of Mathematics)	3 units
Math 350 (Probability)	3 units
Math 360 (Advanced Calculus I)	3 units
Math 375 (Algebraic Systems)	3 units
Math 380 (Geometry)	3 units
Math 405 (Advanced Perspective on Secondary School Mathematics)	3 units
Total	38 - 41 units

Extended studies

Math 305 (Seminar in Teaching Mathematics)	2 units
Two upper-division Math electives	6 units
CS 150 (Computer Programming I)	4 units
Physics 270 (Introduction to Mechanics and Wave Motion)	4 units
Total	16 units

The following table shows the six major Content Domains for the Subject Matter Requirements and the courses in which they are covered.

Coverage of the subject matter requirements in courses:

	Algebra	Geometry	Number Theory	Probability & Statistics	Calculus	History Math
Math 120 Intro Prob & Stat				x		x
Math 150 Calculus I	x				x	
Math 151 Calculus II	x	x			x	x
Math 160 Logic Math & CS	x		x	x	x	
Math 250 Calculus III	x	x			x	
Math 320 Linear Algebra	x	x				
Math 325W History of Math						x
Math 350 Probability	x			x		
Math 360 Adv Calculus I	x				x	
Math 375 Algebraic Systems	x		x		x	x
Math 380 Geometry		x				x
Math 405 Adv Perspective	x	x			x	x
Math 305 Seminar						x
Phys270 Mechanics	x					

Throughout the program students are encouraged to see the connections between their current work and secondary mathematics, but this is particularly emphasized in Math 405 (Advanced Perspective on Secondary School Mathematics). Indeed, this has been a special consideration in selecting the textbook for the course. Some other examples of places where the connections between college mathematics and secondary mathematics are particularly emphasized are in Math 305 (Seminar in Teaching Mathematics)

California State University, Chico

Science: Physics Subject Matter Preparation Program Requirements

The coursework requirements listed for this program have been found by reviewers to meet the Commission's requirements and the content of the program meets the Commission's standards and subject matter requirements. A matrix chart is also included illustrate for Commissioners where the domains of the Science: Physics Subject Matter Requirements are addressed in the program. In the course of the program review, the reviewers examine supporting evidence to determine how and to what extent the domains are covered in the program.

Information from Standard 1 – (The following information was excerpted from the institutional response to Program Standard 1 that asks the institution to describe how its program philosophy and design is related to the Commission's standards and how it reflects and builds on the State-adopted academic content standards for K-12 students and the curriculum frameworks for California public schools.) The Academic Content Standards for K-12 students and Curriculum Frameworks for California public schools center on Glenn T. Seaborg's definition of science: "Science is an organized body of knowledge and a method of proceeding to an extension of this knowledge by hypothesis and experiment." The purpose of the General Physics degree at California State University, Chico is to train students in three general areas: 1) the fundamental principles of science across the disciplines of science, 2)In-depth understanding of the principles of physics and a second science and 3) the process of science, that is, how basic principles are elucidated and evaluated. Thus, the program emphasizes theory and practice across the science disciplines.

To accomplish the first purpose of the program, introductory sequences in physics, chemistry, geoscience and biology are required. These are followed by in-depth courses in physics and a second science chosen by the student. In the introductory sequences in physics, chemistry, geoscience and biology, the fundamental laws of nature and how they relate to the individual disciplines in science are presented. The chemistry classes investigate the principles of atomic structure, chemical bonding, stoichiometry, the periodic table, gases, solids, liquids, solutions and equilibrium. The geoscience courses provide students with a well-rounded exploration of the current scientific understanding of Earth and the cosmos. Students study the composition, active processes, and evolution of a wide variety of systems: the earth's interior and surface, the oceans, the atmosphere, the biosphere and space. In the biological sciences, the introductory sequence emphasizes the common elements of life: ecology, evolution, molecular biology, and genetics.

All of the introductory courses save one include weekly laboratory work. In these settings the third purpose of the program is addressed, the process of science. Here students learn and practice the methods of scientific inquiry that cultivate curiosity, skepticism, objectivity, and observation. Thus, students acquire the skills and habits of mind that will not only enable them to teach science effectively, but also to continue learning about science long after their graduation from college. These qualities are essential for teachers of today's rapidly expanding and evolving body of scientific knowledge and are qualities that can be used to teach science effectively among diverse groups of students. In summary, these introductory courses model

multiple instructional strategies, such as direct instruction, teacher modeling and demonstration, and investigation and experimentation, which are the most effective techniques for teaching science and are the methods advocated by the California Science Framework.

In-depth knowledge of physics is accomplished by an additional year of study in modern physics, a semester of advanced laboratory, a seminar course on current topics, a semester of observation and practice in physics teaching in a local high school physics classroom and two elective advanced physics courses.

The advanced laboratory course develops high level skills in the practice of science using state-of-the-art technologies and demands substantial amounts of technical writing. The seminar course requires students to complete a one-hour presentation to faculty and students on a topic of their choosing. This is a capstone experience requiring students to analyze complex discipline-based issues and synthesize information from multiple sources and perspectives. These courses develop the skills in written and oral communication required for the teaching profession.

In-depth knowledge of a second science chosen by the student is also required by the General Physics degree. This is accomplished through twelve additional units of coursework in the second science.

The "General Physics" degree is specifically designed to meet the criteria of the California Commission on Teacher Credentialing for students that want to become high school physics teachers.

General Education Requirements: 39 units (university requirement is 48 units)
Including Cultural Diversity Requirements: 6 units
Reduced by three courses required below (Math 7A, Biol 6A and Chem 37)

Lower-Division Requirements: 47 units

CHEM	037	General Chemistry	4 units
CHEM	038	General Chemistry	4 units
BIOL	006A	Biological Principles	4 units
BIOL	006B	Biological Principles	4 units
GEOS	002	Physical Geology	3 units
MATH	007A	Analytic Geometry and Calculus	4 units
MATH	007B	Analytic Geometry and Calculus	4 units
MATH	007C	Analytic Geometry and Calculus	4 units
MATH	007D	Elem Diff Equation/Vector Calc	4 units
PHYS	004A	Mechanics	4 units
PHYS	004B	Electricity and Magnetism	4 units
PHYS	004C	Heat/Wave Motion/Sound/Light	4 units

Upper Division Requirements: 16 units

GEOS	100	Earth Science	3 units
PHYS	200A	Modern Physics I	3 units
PHYS	200B	Modern Physics II	3 units
PHYS	227	Advanced Laboratory	3 units
PHYS	289T	Internship in Physics Teaching	3 units
PHYS	291	Physics Seminar	1 unit

Upper Division Physics Electives: 6 units
6 Units selected from any upper-division course in physics.

Science Breadth Electives: 12 units
12 Units selected from any non-General Education courses in Chemistry (CHEM), Biology (BIOL), or Geoscience (GEOS). All 12 units must be selected from one department.

Breadth of Study Program Matrix

The program addresses the subject matter skills and abilities applicable to the content domains in science listed below:

A-Astronomy
B-Dynamic Processes of the Earth (Geodynamics)
C-Earth Resources
D-Ecology
E-Genetics/Evolution
F-Molecular Biology and Biochemistry
G-Cell and Organismal Biology
H-Waves
I-Forces and Motion
J-Electricity and Magnetism
K-Heat Transfer and Thermodynamics
L-Structure and Properties of Matter

Below is a matrix listing the science breadth courses required for the General Physics degree and the Content Domains for Subject Matter Understanding and Skill in General Science. For each sub-domain, a check mark indicates that the sub-domain is addressed in the course indicated. Evidence is contained in the syllabi for each course that is in Appendix E as well as the course descriptions in Appendix B and Appendix C. In more cases than not, the content is included in more than one course that assures not only complete coverage, but also a chance for the student to integrate their knowledge across science disciplines.

COURSE	BIOL 6A	BIOL 6B	CHEM 37	CHEM 38	GEOS 2	GEOS 100	PHYS 4A	PHYS 4B	PHYS 4C
Domain 1.1 Astronomy									
a. Describe the chemical composition and physical structure of the universe						√			
b. Describe the structure of the solar system and its place in the Milky Way galaxy						√			
c. Distinguish between stars and planets						√			
d. Recognize that stars vary in color, size, and luminosity						√			
e. Describe a simple model of how fusion in stars produces heavier elements and results in the production of energy, including light						√			
f. Describe the regular and predictable patterns of stars and planets in time and location						√	√		
g. Explain and predict changes in the moon's appearance (phases)						√			
h. Describe the use of astronomical instruments in collecting data, and use astronomical units and light years to describe distances						√	√	√	√
Domain 2.1 Tectonics									
a. Diagram the features that provide evidence for plate tectonics					√				
b. Summarize the thermal processes driving plate movement					√				
c. Explain how density and buoyancy are related to plate tectonics					√				
d. Describe types of plate boundaries					√				
e. Relate the causes of volcanoes, earthquakes, and earth resources to tectonic processes					√				
f. Summarize earthquake processes					√				
Domain 2.2 Rock Formation									
a. Diagram and explain the rock cycle					√				
b. Describe relative and absolute dating techniques, including how half-lives are used in radiometric dating					√				√
c. Compare uniformitarianism and catastrophism					√				
Domain 2.3 Shaping Earth									
a. Describe the dynamic processes of erosion, deposition, and transport					√				
b. Describe coastal processes including beach erosion and natural hazards					√				
c. Describe the effects of natural hazards					√				
Domain 2.4 Energy & Earth									
a. Diagram the water cycle and describe interrelationships of surface and sub-surface reservoirs					√	√			
b. Explain daily and seasonal changes in the sky						√			
c. Analyze the uneven heating of Earth by the sun						√			
d. Discuss the effects of air movements on weather						√			
e. Describe the energy transfer processes of convection, conduction, and radiation in relation to the atmosphere/ocean and Earth's interior structure						√			

f. Interpret weather maps to predict weather patterns						√			
COURSE	BIOL 6A	BIOL 6B	CHEM 37	CHEM 38	GEOS 2	GEOS 100	PHYS 4A	PHYS 4B	PHYS 4C
Domain 3.1 Earth Resources									
a. Describe a variety of energy resources					√				
b. Recognize earth materials as resources					√				
c. Identify resources as renewable vs. nonrenewable					√				
d. Compare extraction and recycling in relation to energy, cost, and demand					√				
e. Explain sustainable uses of resources with respect to utility, cost, human population, and environmental consequences					√				
Domain 4.1 Ecology									
a. Explain energy flow and nutrient cycling through ecosystems		√							
b. Explain matter transfer		√							
c. Distinguish between abiotic and biotic factors	√								
d. Compare the roles of photosynthesis and respiration	√								
e. Describe interrelationships within and among ecosystems		√							
f. Identify and explain factors that affect population types and size		√							
Domain 5.1 Genetics & Evolut'n									
a. Explain the inheritance of traits	√								
b. Solve problems that illustrate monohybrid and dihybrid crosses	√								
c. Compare sexual and asexual reproduction	√								
d. Explain how the coding of DNA controls the expression of traits	√								
e. Define mutations and explain their causes	√								
f. Explain the process of DNA replication	√								
g. Describe evidence, past and present, that supports the theory of evolution		√							
h. Explain the theory of natural selection		√							
i. List major events that affected the evolution of life on Earth		√							

COURSE	BIOL 6A	BIOL 6B	CHEM 37	CHEM 38	GEOS 2	GEOS 100	PHYS 4A	PHYS 4B	PHYS 4C
Domain 6.1 Bio & Biochem									
a. Demonstrate understanding that a small subset of elements (C, H, O, N, P, S) makes up most of the chemical compounds in living organisms by combining in many ways	√								
b. Recognize and differentiate the structure and function of molecules in living organisms	√								
c. Describe the process of protein synthesis	√								
d. Compare anaerobic and aerobic respiration	√								
e. Describe the process of photosynthesis	√								
Domain 7.1 Cell & Org. Bio.									
a. Describe organelles and explain their function	√								
b. Relate the structure of organelles and cells to their functions	√								
c. Identify and contrast animal and plant cells	√								
d. Explain the conversion, flow, and storage of energy of the cell	√								
e. Identify the function and explain the importance of mitosis and meiosis	√								
f. Compare single-celled and multicellular organisms	√								
g. Describe the levels of organization (e.g., cells, tissues, organs, systems, organisms) in plants and animals		√							
h. Describe the structures and functions of human body systems		√							
i. Explain the major structures and their functions in vascular and nonvascular plants		√							
j. Describe the life processes of various plant groups		√							
k. Explain the reproductive processes in flowering plants		√							
Domain 8.1 Waves									
a. Compare the characteristics of sound, light, and seismic waves					√			√	√
b. Explain that energy is transferred by waves without mass transfer								√	√
c. Explain how lenses are used in simple optical systems									√
d. Explain and apply the laws of reflection and refraction									√
e. Compare transmission, reflection, and absorption of light in matter									√

COURSE	BIOL 6A	BIOL 6B	CHEM 37	CHEM 38	GEOS 2	GEOS 100	PHYS 4A	PHYS 4B	PHYS 4C
Domain 9.1 Forces & Motion									
a. Discuss and apply Newton's laws							√	√	√
b. Define pressure and relate it to fluid flow and buoyancy							√		
c. Describe the relationships among position, distance, displacement, speed, velocity, acceleration, and time							√		
d. Identify the separate forces that act on a body and describe the net force on the body							√	√	√
e. Construct and analyze simple vector and graphical representations of motion and forces							√		
f. Identify fundamental forces, including gravity, nuclear forces, and electromagnetic forces, and explain their roles in nature							√	√	√
g. Explain and calculate mechanical advantages for levers, pulleys, and inclined planes							√		
Domain 10.1 Elec. & Mag.									
a. Describe and provide examples of electrostatic and magnetostatic phenomena								√	
b. Predict charges or poles based on attraction/repulsion observations								√	
c. Build a simple compass and use it to determine direction of magnetic fields								√	
d. Relate electric currents to magnetic fields								√	
e. Design and interpret simple series and parallel circuits								√	
f. Define and calculate power, voltage differences, current, and resistance in simple circuits								√	
Domain 11.1 Heat & Thermo.									
a. Know the principle of conservation of energy and apply it to energy transfers							√	√	√
b. Discuss how the transfer of energy as heat is related to changes in temperature							√		√
c. Diagram the direction of heat flow in a system									√
d. Describe the methods of heat transfer by conduction, convection, and radiation									√
e. Explain how chemical energy in fuel is transformed to heat				√			√		√
f. Design and explain experiments to induce a physical change			√	√					√
g. Distinguish between physical and chemical changes			√	√					√

COURSE	BIOL 6A	BIOL 6B	CHEM 37	CHEM 38	GEOS 2	GEOS 100	PHYS 4A	PHYS 4B	PHYS 4C
Domain 12.1 Matter									
a. Identify, describe, and diagram the basic components within an atom			√						√
b. Know that isotopes of any element have different numbers of neutrons but the same number of protons, and that some isotopes are radioactive			√	√					√
c. Differentiate between atoms, molecules, elements, and compounds			√						
d. Compare and contrast states of matter and describe the role energy plays in the conversion from one state to another			√						
e. Discuss the physical properties of matter including structure, melting point, boiling point, hardness, density, and conductivity			√					√	√
f. Recognize that all chemical substances are characterized by a unique set of physical properties			√	√				√	√
g. Define and calculate density, and predict whether an object will sink or float in a fluid							√		
h. Explain that chemical changes in materials result in the formation of a new substance corresponding to the rearrangement of the atoms in molecules			√	√					
i. Explain and apply principles of conservation of matter to chemical reactions, including balancing chemical equations			√						
j. Distinguish among acidic, basic, and neutral solutions				√					
k. Describe the construction and organization of the periodic table			√						√
l. Based on position in the periodic table, predict which elements have characteristics of metals, semi-metals, non-metals, and inert gases			√						√
m. Explain chemical reactivity using position on the periodic table			√						
n. Predict and explain chemical bonding using elements' positions in the periodic table			√						
o. Recognize that inorganic and organic compounds are essential to processes within living systems	√								
p. Explain the central role of carbon in living system chemistry	√								

Depth of Study Program Matrix

The concentration in physics requires the standard three-semester sequence of 4-unit calculus based lower division courses. These courses cover mechanics (PHYS 4A), electricity and magnetism (PHYS 4B), and sound, thermodynamics, optics and modern physics (PHYS 4C). Upper division requirements include one additional year of modern physics (PHYS 200A & 200B), one semester of laboratory in which modern topics are explored experimentally (PHYS 227), a seminar course in which the student must complete a one-hour presentation (PHYS 291), and two additional courses of the student's choice.

A high level of mathematical skill is required for successful completion of the program. Students are required to complete the standard four-semester sequence of 4-unit calculus courses concurrently with their physics. Differential and integral calculus are used early. Vector calculus and differential equations are used in upper division courses.

Content Domains: Subject Matter Understanding and Skill in Physics

Domain 1. Motion and Forces
Domain 2. Conservation of Energy and Momentum
Domain 3. Heat and Thermodynamics
Domain 4. Waves
Domain 5. Electromagnetism
Domain 6. Quantum Mechanics and the Standard Model of Particles

The content matrix below summarizes the coverage of each of the six physics content domains by each of the relevant physics courses in the program.

COURSE	PHYS 4A	PHYS 4B	PHYS 4C	PHYS 200A	PHYS 200B	PHYS 227
Domain 1.1 Motion & Forces						
a. Solve problems using Newton's Second Law	√	√	√	√	√	√
b. Construct appropriate free-body diagrams	√	√	√	√	√	√
c. Solve periodic motion problems	√	√	√	√	√	√
d. Solve 2-dimensional problems	√	√	√	√	√	√
e. Generate and understand functional relationships of graphs	√	√	√	√	√	
f. Recognize relationships among variables for linear motion and rotational motion	√	√	√	√	√	√
g. Solve problems involving linear and rotational motion in term of forces and torques	√	√	√	√	√	
Domain 2.1 Conservation of Energy and Momentum						
a. Use conservation of energy to characterize kinetic-potential energy systems such as oscillating systems (pendula and springs), projectile motion, and roller coasters	√					
b. Analyze elastic and inelastic collisions and solve for unknown values	√	√	√	√	√	√
c. Solve problems involving linear and rotational motion in terms of conservation of momentum and energy	√	√	√	√	√	√
d. Recognize relationships between energy/momentum conservation principles and Newton's Laws	√	√	√	√	√	
e. Examine the impact of friction on conservation principles	√					
f. Interpret force-versus-time and force-versus-distance graphs to find, for example, work done or impulse on a system	√	√	√			
Domain 3.1 Heat and Thermodynamics						
a. Solve problems involving the laws of thermodynamics using the relationships among work, heat flow, energy, and entropy			√			
b. Define and correctly apply thermodynamic properties of materials such as specific heat (heat capacity), heats of fusion, heat of vaporization, thermal conductivity, and thermal expansion to solve problems			√			
c. Solve problems for ideal gas systems			√			
d. Solve problems involving cyclic processes, including calculations of work done, heat gain/loss, , and entropy change			√			
e. Interpret graphs showing phase changes and graphs of cyclic processes			√			
f. Describe a plasma, state its characteristic properties, and contrast it with an ideal gas			√	√	√	
Domain 4.1 Waves						

a. Relate wave propagation to properties of materials (e.g., predict wave speed from density and tension)		√	√	√	√	
b. Describe, distinguish, and solve both conceptual and numerical problems involving interference, diffraction, refraction, reflection, Doppler effect, polarization, dispersion, and scattering			√	√	√	√
Domain 5.1 Electric and Magnetic Phenomena						
a. Analyze electric and magnetic forces, charges, and fields using Coulomb's law, the Lorentz force, and the right-hand rule		√		√	√	√
b. Apply energy principles to analyze problems in electricity, magnetism, and circuit theory involving capacitors, resistors, and inductors		√				√
c. Calculate power, voltage changes, current, and resistance in multiloop circuits involving capacitors, resistors, and inductors		√				√
d. Interpret and design mixed series and parallel circuits involving capacitors, resistors, and inductors		√				√
e. Solve problems involving the relationships between electric and magnetic phenomena		√	√	√	√	√
f. Explain properties of transistors, diodes, and semiconductors		√				√
Domain 6.1 Quantum Mechanic and the Standard Model of Particles						
a. Distinguish the four fundamental forces of nature, describe their ranges, and identify their force carriers	√			√	√	
b. Evaluate the assumptions and relevance of the Bohr model of the atom			√	√	√	