Physics
Curriculum Framework

Mapping High School Physics to:
Science Cognitive Demands
Texas State Standards: Texas Essential Knowledge Skills, TEKS
Underlying Processes in TEKS assessed in Texas Assessment of Knowledge and Skills, TAKS
National Science Education Standards

The El Paso Collaborative for Academic Excellence

Curriculum Framework for High School Physics

A K-16 group of classroom science and physics teachers, faculty, curriculum specialists, and department chairs met over the course of a year and developed a curriculum framework for high school Physics, an important step in developing explicit and comprehensive goals for teachers in El Paso area schools. The framework is a product of collective work of K-16 classroom teachers and faculty from K-12 schools, El Paso Community College, and the University of Texas at El Paso. It is meant to assist science teachers in ensuring that current high school courses are aligned with first year college science courses entering college freshmen will take. Physics is the most current course in the science alignment process. In previous years, the group developed frameworks for Chemistry and on K-8 Science Frameworks. The expectation is that as teachers use the framework to provide challenging courses and curriculum in science, the number of students who successfully enroll and complete college level science courses will increase. Students will benefit because of collective effort of teachers K-16 who will embrace the next stage in this process: implementation with the goal of providing practical revision. With participation from every high school physics teacher, the framework will become the standard in science coursework for every student in El Paso.

Background

In 1998, the El Paso Collaborative Board identified as its top priorities: 1) continuing to focus on mathematics and 2) the alignment of the mathematics curriculum. A review of local data on mathematics achievement showed larger numbers of students enrolled in and completing college preparatory mathematics courses in high school. It also revealed a continuous increase in student achievement on TAAS. This higher student achievement however, did not reflect student readiness for college mathematics courses. Gaps also existed in high school science preparation for entering college freshmen. Further review of data revealed that large numbers of high school students were placing and enrolling in remedial courses as well as large numbers of students not succeeding in the freshman science courses at El Paso Community College and the University of Texas at El Paso. While many factors contribute to these large numbers, one known factor is that there was little alignment between what high school teachers expect students to know and be able to do and the expectations of college and university faculty.

To deal with some of these issues, the Mathematics and Science Partnership, MSP, proposed and was funded to continue supporting alignment of mathematics curriculum, assessment, and instruction and to initiate alignment of science K-16. Included in MSP's goals and objectives is to provide students with challenging courses and curriculum in high school mathematics and science courses that prepare them to enroll in and successfully complete college level mathematics and science courses.

Working Group

Starting in Fall 2003, MSP convened a working group of classroom teachers to write curriculum frameworks for Chemistry, Physics, Biology and K-8 Science for teachers to use as curriculum guides no matter what instructional materials they were using for the course. The Working Group included: K-12 classroom teachers from both urban and rural independent school districts; mathematics and science staff developers, specialists in science from both rural and urban school districts; science instructors from El Paso Community College; and professors representing the Colleges of Education and Science from the University of Texas at El Paso. A complete list of participants in the K-16 Science Working Group is attached.

To prepare for writing curriculum framework for K-8 and high school science courses, the Group engaged in dialogue and discussion focused on science teaching and learning. Using whole and small group formatted discussions, the K-16 Science Working Group:

- analyzed and discussed student performance in science using data collected from state mandated assessments and performance in college freshman courses;
- examined textbooks, course requirements, outline format, state, national, and placement tools used to assess student readiness for college;
- reviewed the Texas Essential Knowledge and Skills (TEKS) and National Science Education Standards, Atlas of Science Project 2061;
- discussed how concepts were connected and developed in grade levels and how they led to concepts incorporating higher cognitive demands in science;
- identified alternate ways of assessing student learning that provide for standards-based assessment;
- discussed models of teaching science; and
- reviewed and discussed science education literature.

Meeting bimonthly during the academic year and for several days in summer the Group wrote curriculum frameworks for Chemistry, Physics and K-8 Science. Content for the course was placed in text outline form as well as matrix form to map content topics to cognitive demands as well as to state (TEKS) and national science standards.

K-16 Leaders Group

A leaders group made up of district leaders and central office personnel from both urban and rural independent school districts and the Education Service Center for Region 19, the provost of the University, science and education deans and mathematics and science department chairs from both the Community College and University, and lead principals and teachers from the districts, was also convened to dialogue and discuss issues in mathematics education. As an advisory group, they discussed and engaged in focused dialogue around issues in science education and provided guidance and feedback in the development of the K-16 Mathematics and Science frameworks.

Needs

What we need now is assistance from high school principals and teachers who will help review, revise and make practical use of the framework during the academic year. Ideally, the Physics curriculum framework should be reviewed by every high school science teacher particularly by teachers of physics to help prioritize aligning science curriculum, instruction, and assessment, K-16. In order to continue this work, we need participation from every science department in every school in the both urban and rural independent school districts and by postsecondary physics faculty and chairs.

Call 747-5778 for more information on how you can be involved in reviewing and revising these frameworks.

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K-16 SCIENCE ALIGNMENT WORKING GROUP

Maria Luisa Arroyo	SISD	El Dorado HS	2004 – present
Socorro Arteaga, Ph. D.	EPCC	Chemistry	2003 – present
Karen Blaine	Region 19	MSP Staff Dev	2004 – 2005
Sally Blake, Ph. D.	UTEP	Science Education	2003 – 2006
Amy Canales	SISD	Science Specialist ES	2003 – present
Evangelina Cantu	SISD	Science Specialist HS	2004 – present
Deborah Caskey	EPCC	Geology	2004 – present
William Cornell, Ph. D.	UTEP	Geology	2005 – present
Karen Davis	Region 19	MSP Staff Dev	2003 – 2004
Olga Deslongchamps	YISD	Parkland HS	2003 – present
Sylvia Esparza	SISD	Socorro HS	2003 – 2005
Maritza Fernandez	YISD	Hacienda Heights ES	2004 – 2005
Sandy Garza	SISD	Science Specialist ES	2003 – 2004
Jeannie Geske	EPISD	Bond ES	2003 – present
Kristin Gosselink, Ph. D.	UTEP	Biology	2005 – present
Eric Hagedorn, Ed. D.	UTEP	Physics	2003 – 2005
Kastro M. Hamed, Ph. D	UTEP	Physics	2003 – 04, 06 – present
Terry Jimarez	UTEP	College of Science	2003 – 2004
Kathy Kraften	EPISD	MSP Staff Dev	2003 – present
Richard Langford, Ph. D.	UTEP	Geology	2005 – present
Carl Lieb, Ph. D.	UTEP	Biology	2004 – present
Mary Liggett	SISD	Socorro MS	2003 – 2005
Jorge Lopez, Ph. D.	UTEP	Physics	2004
Victor Macias	SISD	El Dorado HS	2003 – Aug. 2004
Jose Maldonado	EPCC	Biology	2003 – present
Michael Martin	SISD	Bill Sybert K-8	2006
Nancy Marcus, Ph. D.	UTEP	Mathematics	2003
Emil Michal	EPCC	Physics	2003 – present
Diana Noriega	YISD	Cadwallader ES	2003 – present
Gloria Ontiveros	YISD	Ranchland Hills MS	2003 – present
Myriam Sanchez	SISD	Sambrano ES	2003 – 2005
Luis Saez, Ph. D.	UTEP	Physics	2004
Cynthia Stone	SISD	Science Specialist ES	2003 – 2004
Virginia Tovar	EPISD	Jefferson HS	2003 – 2004
Enrique Villalobos	SISD	MSP Staff Dev	2003 – 2005
Diane Walker	YISD	MSP Staff Dev	2003 – present

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PHYSICS COURSE OUTLINE

I. COURSE DESCRIPTION

Physics is the study of natural phenomena in the world around us. It forms the basis of all science. The study of physics engages students in scientific inquiry to explain and help them understand forces of nature and interactions of matter, space, and time. Physics attempts to explain stars, galaxies, planetary motions, electricity, energy, and why an apple falls. Physics takes students on an adventure with scientists like Einstein and Newton in learning how and why the world operates through relationships between matter and energy. The course assists students in using physics to ponder questions like: Why are we here? Where do we come from? Where are we going? Physics prepares students pursuing careers in engineering, medicine, teaching, technology, and other sciences. Beyond that, students come to understand the magic of physics as they participate in learning it.

II. PREREQUISITE KNOWLEDGE

Students entering physics must know about and be able to apply:

A. Phenomena: optics, sound, motion, electricity, and magnetism
B. Science Process Skills: demonstrate observational skills, perform experiments, formulate questions, inquire, make predictions given data,
C. Mathematics and algebraic skills: solve equations, read graphs, take measurements
D. Critical reading and writing skills
E. Imagination
F. Transfer of knowledge from concrete to abstract and from abstract to concrete

III. CONTENT

In Physics, students will focus on knowing and learning to apply:

A. All listed in II above, but at a higher cognitive and mathematical level
B. Physics in their world
C. Critical thinking and scientific problem solving
D. Physics to make decisions
E. Connections between science disciplines
F. Concepts of energy and matter
G. Principles of physics
H. How change occurs

IV. ASSESSMENT

A. It is suggested that a variety of methods should be used to assess student learning. This includes assessments that show student work as well as student explanations of their work. These assessments might include both traditional and alternative methods such as:
   1. Performance-based tasks
   2. Open book (including homework)
   3. Technology-based presentations
   4. Interviews
   5. Observations

6. Projects
7. Portfolios
8. Projects with rubrics (individual and group)
9. Multiple choice
10. Open response
11. Comprehensive, multi-step problems
12. Final comprehensive exam

B. Recommended Course Grade – Each district has guidelines for course grades and, whenever possible, it is recommended that the final course grade for students be determined by a combination of the following:
   1. 25 % from formative assessments (daily tools such as warm-ups, quizzes, teacher observations and interviews, group work)
   2. 35% from closed book assessments (constructed response, multiple choice, quantitative comparisons, SAT problems, multi-step problems)
   3. 25% from open book assessments (homework, projects, presentations, portfolios)
   4. 15% from a Final Comprehensive Exam

V. TIMELINE

A brief overview of everyday applications of physics principles may be given during the first week of the semester. It is recommended that the rest of the time should be allotted to cover the course and that any further review be embedded in the following units as needed. Some districts have their own timeline embedded in their scope and sequence work. If a district or school does not have an agreed upon timeline, teachers should convene to agree on a recommended distribution of time allotted to cover the following units appropriately.

A.	Principles of Motion	_____%
B.	Conservation of Energy and Momentum	_____%
C.	Forces in Nature	_____%
D.	Principles of Thermodynamics	_____%
E.	Waves and Quantum Physics	_____%

VI. INFORMATION/RESOURCES FOR STUDENTS

A. Course description
B. Teacher information (conference period, office hours)
C. Work, projects, homework, exams, etc., to be produced by the students including grading policy for each
D. Rubrics for projects/presentations/portfolios
E. Resources – tutoring, lab, Internet web sites specific to the course, computer programs, teacher conference period, other outside support available
F. Weekly calendar
G. Materials: It is recommended that a textbook and graphing calculator package be issued to each student.
H. CBL – Calculator Based Lab; CBR – Calculator Based Range, LapPro

VII. MATRIX MAPPING TOPICS TO COGNITIVE DEMANDS

A. Attached is a matrix that matches cognitive demands to topics in Physics. The work on cognitive demands has been guided by work of Andrew Porter, Norman Webb, and John Smithson. The cognitive demands identified by Porter, Webb, and Smithson were used as models and modified by the working group to fit our work in high school science courses. These identify thinking levels that incorporate five (5) levels of cognitive demands. They are listed on the matrix from higher order to lower order as you read from left to right. Frameworks also map topics to state and national standards and for some courses, frameworks also map textbook and materials used in major independent school districts.

B. Cognitive Demands for Science

Cognitive demands assist teachers in distinguishing what a student is expected to know and be able to do with science content, and what level of thinking students must be engaged in while learning content. This mapping of topics to cognitive demands describes content knowledge that will not merely be stored, but also understood, represented, organized, connected, and structured in ways that facilitate retrieval and application of knowledge. With cognitive demands, teachers know how to get student to use, represent and connect pieces of content knowledge in coherent ways that will determine whether students understand knowledge deeply and can use it to solve new problems. They are:

1. **Analyze Information –** classify and compare data; analyze data, recognize patterns; reason inductively or deductively; draw conclusions; identify faulty arguments or misrepresentations of data; spatial reasoning

2. **Apply Concepts/Make Connections –** apply and adapt science information to real-world situations; apply science ideas outside the context of science; build or revise theory, plan and design experiments; synthesize content and ideas from several sources; use and integrate science concepts

3. **Understand Concepts** – explain concepts, observe and explain teacher/student demonstrations; explain procedures and methods of science and inquiry; organize and display data in tables or charts; present science information; construct or use models to represent science ideas

4. **Perform Procedures/Conduct Investigations –** make observations; collect and record data; use appropriate tools; make measurements, do computations; organize and display data in tables or charts; execute procedures; generate questions, make predictions; conduct experiments; test effects of different variables; select, use appropriate tools

5. **Memorize Facts, Definitions, Formulas –** recite basic science facts; recall science terms and definitions; recall scientific formula

C. Matrix Format and Its Use as A Teaching and Learning Tool

1. Strands and topics in matrices overlap and may be integrated
3. Cognitive demands overlap and are neither linear nor sequential.
4. TEKS are categorized in four strands:
    a. Nature of Science (TEKS c1 – c3);
    b. Constancy and Change (TEKS c4);
    c. Properties, Patterns, and Models (TEKS c9); and

d. Systems (TEKS c5 – c7, c9)

5. Items in the matrix appearing in regular fonts are actual TEKS and are placed within a suggested cognitive demand.
6. Italicized items support teaching and learning at a higher level of cognitive demand that leads

    to conceptual understanding of a topic/concept; these may not have a referenced TEKS but are meant to support learning of TEKS with understanding

    b. paraphrase TEKS to address different levels of cognitive demands; these will reference TEKS and are placed under multiple cognitive demands

Physics Framework Matrix Mapping Knowledge and Skills to Cognitive Demands

Knowledge and Skills	**Cognitive Demands**				
	Analyze Information	**Apply Concepts/ Make Connections**	**Understand Concepts**	**Perform Procedures/ Conduct Investigations**	**Memorize**
Nature of Science **The student:** c1 for at least 40% of the time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. c2 uses scientific methods during field and laboratory investigations. c3 uses critical thinking and scientific problem solving to make informed decisions **June 2005**	c1B Make wise choices in the use and conservation of resources and the disposal or recycling of materials c2C *Organize, analyze and evaluate trends from data* *c3A Analyze and review scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information*	c2C *Make inference and predict trends from data* *c2E Identify relationships between variables* *c2A Plan experimental procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology* *c3A Critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information* c3C Evaluate the impact of research on scientific thought, society and the environment	c1A Demonstrate safe practices during field and laboratory investigations c2D Communicate valid conclusions c3D Describe the connection between physics and future careers *c3B Express laws symbolically to solve physical problems*	*c2A Implement experimental procedures including asking questions and selecting equipment and technology* c2B Make quantitative observations and measurements with precision *c2E Graph data to observe relationships between variables* c2F Read the scale on scientific instruments with precision *c3B Employ mathematical procedures including vector addition and right-triangle geometry to solve physical problems* c3E Research and describe the history of physics and contributions of scientists	Vocabulary: Meniscus Calibrate instruments Precision Accuracy Vector Right triangle
Timeline	**Textbooks and Materials**		**National Science Standards**		
			9 -12A Science as Inquiry 9 - 12B Physical Science 9 - 12E Science and Technology 9 -12F Science in Personal and Social Perspectives 9 -12G History and Nature of Science		

Physics Framework Matrix Mapping Knowledge and Skills to Cognitive Demands

Knowledge and Skills	**Cognitive Demands**				
	Analyze Information	**Apply Concepts/ Make Connections**	**Understand Concepts**	**Perform Procedures/ Conduct Investigations**	**Memorize**
Constancy and Change	c1, c2, c3	c1, c2, c3	c1, c2, c3	c1, c2, c3	c1, c2, c3
c4 The student knows the laws governing motion. **June 2005**	c4B Analyze examples of uniform and accelerated motion including linear, projectile, and circular c4D *Interpret a free body diagram for force analysis*	c4A Generate and interpret graphs describing motion including the use of real-time technology c4C Demonstrate the effects of forces on the motion of objects *c4D Develop a free body diagram for force analysis* *c4E Describe motion relative to different frames of reference*	*c4E Identify motion relative to different frames of reference*		Vocabulary: motion force uniform motion accelerated motion linear projectile circular free body diagram relativity frame of reference
Timeline	**Textbooks and Materials**			**National Science Standards**	
				9 - 12A Science as Inquiry 9 - 12B Physical Science 9 – 12E Science and Technology	

Physics Framework Matrix Mapping Knowledge and Skills to Cognitive Demands

Knowledge and Skills	Cognitive Demands				
	Analyze Information	**Apply Concepts/ Make Connections**	**Understand Concepts**	**Perform Procedures/ Conduct Investigations**	**Memorize**
Properties, Patterns, and Models c8 The student knows the characteristics and behavior of waves. **June 2005**	c1, c2, c3	c1, c2, c3	c1, c2, c3	c1, c2, c3	
	c8C Interpret the role of wave characteristics and behaviors found in medicinal and industrial applications	c8B Identify the characteristics and behaviors of sound and electromagnetic waves	*c8A Describe wave characteristics such as velocity, frequency, and amplitude, and behaviors such as reflection, refraction, and interference*	c8A *Examine and describe a variety of waves propagated in various types of media*	Vocabulary: waves velocity frequency amplitude reflection refraction interference electromagnetic constructive destructive propagated

Timeline	Textbooks and Materials	National Science Standards
		9 - 12A Science as Inquiry 9 - 12B Physical Science

Physics Framework Matrix Mapping Knowledge and Skills to Cognitive Demands

Knowledge and Skills	**Cognitive Demands**				
	Analyze Information	**Apply Concepts/ Make Connections**	**Understand Concepts**	**Perform Procedures/ Conduct Investigations**	**Memorize**
Systems	c1, c2, c3	c1, c2, c3	c1, c2, c3	c1, c2, c3	
c5 The student knows that changes occur within a physical system and recognizes that energy and momentum are conserved. c6 The student knows forces in nature. **June 2005**	c5A Interpret evidence for the work-energy theorem *c6C Analyze the influences of charge and distance on electric forces* *c6E Analyze electric circuits*	*c5C Make connections between mechanical energy and momentum in a physical system such as billiards, cars, and trains* *c6E Design electric circuits* c6F Identify examples of electrical and magnetic forces in everyday life	*c5B Describe examples of kinetic and potential energy and their transformations* c5D Demonstrate the conservation of energy and momentum c6A Identify the influence of mass and distance on gravitational forces	*c5B Observe examples of kinetic and potential energy and their transformations* c5C Calculate the mechanical energy and momentum in a physical system such as billiards, cars, and trains c6B Research and describe the historical development of the concepts of gravitational, electrical, and magnetic force c6D Demonstrate the relationship between electricity and magnetism	Vocabulary: Work Kinetic energy Potential energy Mechanical Energy Momentum Conservation of energy Conservation of momentum Electric circuits Electric forces Gravitational forces *c6C Identify the influences of charge and distance on electric forces*

Timeline	**Textbooks and Materials**	**National Science Standards**
		9 -12A Science as Inquiry 9 -12B Physical Science

Physics Framework Matrix Mapping Knowledge and Skills to Cognitive Demands

Knowledge & Skills	Cognitive Demands				
	Analyze Information	**Apply Concepts/ Make Connections**	**Understand Concepts**	**Perform Procedures/ Conduct Investigations**	**Memorize**
Systems	c1, c2, c3	c1, c2, c3	c1, c2, c3	c1, c2, c3	c1, c2, c3
c7 The student knows the laws of thermodynamics. c9 The student knows simple examples of quantum physics. **June 2005**	*c7A Analyze everyday examples of the laws of thermodynamics* c7B Evaluate different methods of heat energy transfer that result in an increasing amount of disorder	*c7A Explain everyday examples that illustrate the laws of thermodynamics*	*c7A Recognize everyday examples that illustrate the laws of thermodynamics* c9B Explain the line spectra from different gas-discharge tubes c9A Describe the photoelectric effect	*c7B Demonstrate different methods of heat energy transfer that result in an increasing amount of disorder*	Laws of Thermodynamics Formulas Types of heat energy transfer Photoelectric Spectra Quantum physics

Timeline	**Textbooks and Materials**	**National Science Standards**
		9-12A Science as Inquiry 9-12B Physical Science