



Mississippi Department of Education


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Office of Career Education and Workforce Development

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TO: District Superintendents and Secondary Vocational Directors/Contact Persons

FROM: Jean Massey,  Associate State Superintendent
Office of Vocational Education and Workforce Development

DATE: October 22, 2010

RE: **Revised Secondary Curriculum Framework**

The State Board of Education, on October 22, 2010, gave final approval to the Office of Vocational Education and Workforce Development for the following items:

The revised Mississippi Secondary Curriculum Frameworks for the following secondary programs

1. Video Game Design
2. Concepts of Agriscience of AEST
3. Science of Agricultural Animals
4. Science of Agricultural Environment
5. Science of Agricultural Mechanization
6. Science of Agricultural Plants

A copy of the secondary curriculum can be downloaded from the following site:

<http://www.mde.k12.ms.us/vocational/OVTE/>

If additional information is needed, please contact Jean Massey at (601) 359-3461.

JM:cb

c: Bill McGrew

MEMORANDUM#10.093

"Quality Education for Every Child"

Central High School Building • 359 North West Street • P.O. Box 771 • Jackson, MS 39205-0771

OFFICE OF INSTRUCTIONAL ENHANCEMENT AND INTERNAL OPERATIONS
Summary of State Board of Education Agenda Items
October 21-22, 2010

OFFICE OF VOCATIONAL EDUCATION AND WORKFORCE DEVELOPMENT

Approval to revise the Mississippi Secondary Curriculum Frameworks
(Has cleared the Administrative Procedures Act process with no public comments.)

EXECUTIVE SUMMARY

The secondary curriculum framework, Video Game Design, is recommended for approval. This developmental curriculum will be piloted during the 2010-2011 school year.

In addition, the following secondary curriculum frameworks are recommended for approval:

1. Concepts of Agriscience of AEST
2. Science of Agricultural Animals
3. Science of Agricultural Environment
4. Science of Agricultural Mechanization
5. Science of Agricultural Plants

These approved secondary curricula will be disseminated for implementation in the Spring 2011. Each curriculum framework follows the established format established for secondary vocational and technical programs. Draft curricula for each program were revised and reviewed with input from local district personnel and business/industry collaborators.

The *Executive Summary-Secondary Curricula Frameworks* contains the following elements for each revised secondary curricula:

- ❖ Program Description
- ❖ CIP Code and CIP Name
- ❖ Course Outline and Codes
- ❖ Curriculum Framework
 - Student Competencies
 - Suggested Student Objectives

All curricula frameworks are designed to provide local programs with a foundation that can be used to develop localized instructional management plans and course syllabi. Contents of each framework are not designed to limit the content of a course, but to provide a minimum baseline of instruction, which all programs must meet.

Teachers, administrators, and instructional management personnel are encouraged to expand and enhance the statewide frameworks to better meet the needs of their students.

Recommendation: Approval

Back-up material attached

FRAMEWORKS FOR
VOCATIONAL-TECHNICAL PROGRAMS
REVISED IN
2010

SECONDARY
EXECUTIVE SUMMARY

2010

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Foreword

Secondary vocational-technical education programs in Mississippi are faced with many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing true learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, Mississippi Code of 1972, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, ch. 487, §14; Laws, 1991, ch. 423, §1; Laws, 1992, ch. 519, §4 eff. from and after July 1, 1992; Carl D. Perkins Vocational Education Act III, 1998; and No Child Left Behind Act of 2001).

Each secondary vocational-technical course consists of a series of instructional units which focus on a common theme. All units have been written using a common format which includes the following components:

- Unit Number and Title
- Suggested Time on Task - An estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75-80 percent of the time in the course.
- Competencies and Suggested Objectives
 - A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies.
 - The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.
- Suggested Teaching Strategies - This section of each unit indicates strategies that can be used to enable students to master each competency. Emphasis has been placed on strategies which reflect active learning methodologies. Teachers should feel free to modify or enhance these suggestions based on needs of their students and resources available in order to provide optimum learning experiences for their students.
- Suggested Assessment Strategies - This section indicates strategies that can be used to measure student mastery. Examples of suggested strategies could include rubrics, class participation, reflection, and journaling. Again, teachers should feel free to modify or enhance these suggested assessment strategies based on local needs and resources.

- Integrated Academic Topics, Workplace Skills, Technology Standards, and Occupational Standards - This section identifies related academic topics as required in the Subject Area Assessment Program (SATP) in Algebra I, Biology I, English II, and U. S. History from 1877, which are integrated into the content of the unit. It also identifies the 21st Century Skills, which were developed by the Partnership for 21st Century Skills, a group of business and education organizations concerned about the gap between the knowledge and skills learned in school and those needed in communities and the workplace. A portion of the 21st Century Skills addresses learning skills needed in the 21st century, including information and communication skills, thinking and problem-solving skills, and interpersonal and self-directional skills. The need for these types of skills have been recognized for some time and the 21st Century Skills are adapted in part from the 1991 report from the U.S. Secretary of Labor's Commission on Achieving Necessary Skills (SCANS). Another important aspect of learning and working in the 21st century involves technology skills, and the International Society for Technology in Education, developers of the National Education Technology Standards (NETS), were strategic partners in the Partnership for 21st Century Skills.
- References - A list of suggested references is provided for each unit. The list includes some of the primary instructional resources that may be used to teach the competencies and suggested objectives. Again, these resources are suggested and the list may be modified or enhanced based on needs and abilities of students and on available resources.

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VIDEO GAME DESIGN AND DEVELOPMENT

Program Description

Video Game Design and Development is a pathway in the Science, Technology, Engineering, and Mathematics (STEM) career cluster. This program is designed for students who wish to develop, design, and implement projects in the ever-expanding field of game design and development. The program emphasizes the techniques and tools used in game design and the creative design or content of such media. Both theoretical learning and activity-based learning are provided for students who wish to develop and enhance their competencies and skills. The program focuses on the basic areas of ethics, character development, audio and video production, and design using visualization software. The program finishes with a performance-based unit that requires students to develop their own gaming environment. This comprehensive project component provides practical experience toward developing a portfolio of work. Membership is encouraged in the student organization, Technology Student Association (TSA), which promotes technological literacy, leadership, and problem solving, resulting in personal growth and opportunity.

Industry Certification

Research with Mississippi industry suggests that this curriculum should be written to the Autodesk Certified Associate Certification. This exam assesses the foundation of animation skills students need to create effective animation using game design tools.

Articulation

An articulation agreement is currently under development. As soon as the agreement is finalized, this document will be updated to reflect the agreement.

Assessment

Students will be assessed using the Video Game Design and Development test. The MS-CPAS2 blueprint can be found at <http://redesign.rcu.msstate.edu/curriculum/>. If there are questions regarding assessment of this program, please contact the STEM instructional design specialists at the Research and Curriculum Unit at 662.325.2510.

Student Prerequisites

An eligible student must have completed the ninth grade and Algebra I and must have an overall B average. Prior to a student's being enrolled in the course, a behavior reference must be obtained from an academic technology teacher.

Course Specification

The recommended class size is *20 students per class*. The district will be responsible for providing and maintaining all equipment, providing proper security, replacing missing equipment, and providing annual funds for operation of the program.

Proposed Applied Academic Credit

The academic credit is still pending for this curriculum.

Licensure Requirements

The 988 license is needed to teach the Video Game Design and Development program. The requirements for the 988 license endorsement are listed below:

1. Applicant must have a 4-year degree in a related field or one approved by the Mississippi Department of Education (MDE).
2. Applicant must enroll immediately in the Vocational Instructor Preparation (VIP) program or the College and Career Readiness Education Program (CCREP).
3. Applicant must complete the individualized Professional Development Plan (PDP) requirements of the VIP or CCREP prior to the expiration date of the 3-year vocational license.
4. Applicant must possess and maintain Autodesk Certified Instructor (ACI).
5. Applicant must successfully complete the MDE-approved Internet and Computing Core Certification (IC³).
6. Applicant must successfully complete certification for an online learning workshop, module, or course that is approved by the MDE.
7. Applicant must successfully complete a video game design and development certification workshop, module, or course that is approved by the MDE.

Note: If an applicant meets all requirements listed above, that applicant will be issued a 988 endorsement—a 5-year license. If an applicant does not meet all requirements, the applicant will be issued a 3-year endorsement license, and all requirements stated above must be satisfied prior to the ending date of that license.

Professional Learning

The professional learning itinerary for the middle school or individual pathways can be found at <http://redesign.rcu.msstate.edu>. If you have specific questions about the content of each training session provided, please contact the Research and Curriculum Unit at 662.325.2510, and ask for the Professional Learning Specialist.

Course Outlines

This curriculum framework allows for local school districts to meet student needs and scheduling demands. The first option groups units into four one-Carnegie-unit courses. The second option groups units into two two-Carnegie-unit courses. A discussion of each option is listed below.

The first three courses of the Video Game Design and Development program (Ethics, Design Theory, and Photography; Design Visualization and Character Development; Audio and Video Production) introduce students to the principles and skills associated with game design and

development technology as related to meeting the needs of clients and producing game design products. Business, Evaluation, and Development of Gaming concentrates on video game production, a directed group project, and portfolio finalization. These courses must be taken in sequential order.

Option 1

By following this course of study for Video Game Design and Development, the students will progress through a series of four one-credit courses that should be completed in the following sequence:

1. Ethics, Design Theory, and Photography (Course Code: 994402)
2. Design Visualization and Character Development (Course Code: 994403)
3. Audio and Video Production (Course Code: 994404)
4. Business, Evaluation, and Development of Gaming (Course Code: 994405)

Course Description: Ethics, Design Theory, and Photography (Course Code: 994402). This first course in the program identifies the foundation skills necessary in the game design industry. Content such as safety, ethical issues, video game history, career opportunities, game mechanics, and photography will be offered to students.

Course Description: Design Visualization and Character Development (Course Code: 994403). This course will emphasize real-world, hands-on practice. Content related to illustration, level design, character development, and animation will be offered to students. This one-Carnegie-unit course should only be taken after students successfully pass Ethics, Design Theory, and Photography (Course Code: 994402).

Course Description: Audio and Video Production (Course Code: 994404). This course focuses on audio design, programming, and video production. This one-Carnegie-unit course should only be taken after students successfully pass Design Visualization and Character Development (Course Code: 994403).

Course Description: Business, Evaluation, and Development of Gaming (Course Code: 994405). This is the capstone course that gives students the opportunity to produce a final video game project that incorporates the skill and knowledge learned in the first three Video Game Design and Development courses, giving the students the chance to showcase what they have learned and accomplished. Upon the completion of this course, the students will also have put the finishing touches on a video game portfolio that is cumulative of their work throughout all semesters of Video Game Design and Development. This is a one-Carnegie-unit course and should be taken after students successfully pass Ethics, Design Theory, and Photography (Course Code: 994402), Design Visualization and Character Development (Course Code: 994403), and Audio and Video Production (Course Code: 994404).

Ethics, Design Theory, and Photography (One Carnegie Unit) - Course Code: 994402

Unit	Title	Hours
1	Introduction, Safety, and Orientation	10
2	Ethics in the Game Design Industry	20
3	Games and Society	20

4	Game Design Theory and Mechanics	60
5	Photography for Game Design	30
		140

Design Visualization and Character Development (One Carnegie Unit) - Course Code: 994403

Unit	Title	Hours
6	Artistic Rendering Using Illustration Software	30
7	Design Visualization Software Introduction	10
8	Geometry in Design Visualization Software	20
9	World Design Using Design Visualization Software	30
10	Character Development and Animation	50
		140

Audio and Video Production (One Carnegie Unit) - Course Code: 994404

Unit	Title	Hours
11	Audio Design	40
12	Video Game Programming	60
13	Video Game Production	40
		140

Business, Evaluation, and Development (One Carnegie Unit) - Course Code: 994405

Unit	Title	Hours
14	Business of Gaming	40
15	Video Game Design and Development Seminar and Experience	80
16	Game Evaluation	20
		140

Option 2

By following this course of study for Video Game Design and Development, the students will progress through two two-credit courses that should be completed in the following sequence:

1. Video Game Design and Development I (Course Code: 994400)
2. Video Game Design and Development II (Course Code: 994401)

Course Description: Video Game Design and Development I encompasses the foundation skills necessary in the game design industry. Content such as safety, ethical issues, video game history, career opportunities, game mechanics, and photography with emphasis placed on real-world, hands-on practice related to illustration, level design, character

development, and animation is offered to students. Students will receive two Carnegie units upon completion of the course.

Course Description: Video Game Design and Development II focuses on audio design, programming, and video game production. This course gives students the opportunity to produce a final video game project that incorporates the skills and knowledge learned in the Video Game Design and Development I course, allowing the students the chance to showcase what they have learned and accomplished. Upon the completion of this course, the students will also have put the finishing touches on a video game portfolio that is cumulative of their work throughout all semesters of Video Game Design and Development. Students will receive two Carnegie units upon completion of the course.

Video Game Design and Development I (Two Carnegie Units) - Course Code: 994400

Unit	Title	Hours
1	Introduction, Safety, and Orientation	10
2	Ethics in the Game Design Industry	20
3	Games and Society	20
4	Game Design Theory and Mechanics	60
5	Photography for Game Design	30
6	Artistic Rendering Using Illustration Software	30
7	Design Visualization Software Introduction	10
8	Geometry in Design Visualization Software	20
9	World Design Using Design Visualization Software	30
10	Character Development and Animation	50
		280

Video Game Design and Development II (Two Carnegie Units) - Course Code: 994401

Unit	Title	Hours
11	Audio Design	40
12	Video Game Programming	60
13	Video Game Production	40
14	Business of Gaming	40
15	Video Game Design and Development Seminar and Experience	80
16	Game Evaluation	20

Pathway Name: Video Game Design

CIP Code: 11.0803

ETHICS, DESIGN, THEORY, AND PHOTOGRAPHY

Introduction, Safety, and Orientation

1. Identify course expectations, school policies, program policies, and safety procedures related to Video Game Design and Development.
 - a. Identify course expectations, school policies, and program policies related to Game Design Technology.
 - b. Apply safety procedures in the computer classroom and lab.
2. Explore personality development, leadership, and teamwork in relation to the classroom environment, interpersonal skills, and others.
 - a. Identify potential influences that shape the personality development including personality traits, heredity, and environment.
 - b. Develop a report on how personality traits affect teamwork and leadership skills.
 - c. Identify forces that shape personality development including personality traits, heredity, and environment.
 - d. Develop effective leadership, decision-making, and communication skills.

Ethics in the Game Design Industry

1. Research copyright rules, regulations, and issues related to graphics and images produced by others and original work, and adhere to those rules and regulations when developing work.
 - a. Define terms related to copyright rules, regulations, and issues related to graphics and images produced by others and original work.
 - b. Research copyright laws related to graphics, images, video games, sounds, and other original work.
 - c. Give examples of copyright violations related to trademark, symbols, length of time, and public domain.
 - d. Prepare images, songs, sounds, and video that meet copyright guidelines.
2. Research online content, and evaluate content bias, currency, and source.
 - a. Determine how to search for information online.
 - b. Correlate information with multiple sources.
3. Define and abide by the game designer's code of ethics
 - a. Define terms related to the game design code of ethics.
 - b. Identify the similarities and differences between game ratings.
 - c. Demonstrate the ability to create and follow a personal code of ethics.
 - d. Demonstrate proper use of pictures, sounds bites, and videos.
 - e. Discuss plagiarism and the consequences of plagiarizing.
 - f. Describe the Philosophical Approach to Morality and the consequentialist theory.

Games and Society

1. Understand how games reflect and construct individuals and groups.
 - a. Discuss the historical aspects of game design and development technology in order to analyze the emergence of the “culture” of gaming.
 - b. Discuss the game market and the reasons why people play video games.
 - c. Understand the key elements in game design and development technology.
 - d. Demonstrate an understanding of game genres.
2. Research and identify careers and roles within the game design and development industry.
 - a. Describe the responsibilities of producers, programmers, artists, designers, riggers, animators, modelers, writers, and quality assurance personnel function in relation to the daily operation of a game design company to include budgets, schedules, personnel, and tracking progress.
 - b. Discuss the job outlook for producers, programmers, artists, designers, and quality assurance personnel.
 - c. Understand the organizational structure of a game design company.
3. Develop a professional portfolio.
 - a. Research career areas in design and/or print production.
 - b. Identify the purpose of a portfolio as it relates to career planning.
 - c. Construct a portfolio.
 - d. Present a portfolio.
4. Discuss the future of video games.
 - a. Research the future of game design and development in terms of new technology and education.
 - b. Discuss the concept of an “ideal” game of the future.

Game Design Theory and Mechanics

1. Identify the core components of game design theory and mechanics.
 - a. Discuss the core components of game design theory and mechanics.
 - b. Discuss storytelling traditions and how it influences game ideas. “A good game is like a good novel. You fall in love with the characters, and—though details might fade—when you come back to re-examine them, that sense of magic in story comes right back.” Jed Smith.
 - c. Determine the steps in creating and editing a game design document.
 - d. Demonstrate use of a traditional story structure *three-act* plot structure.
 - e. Demonstrate use of the *monomyth* story structure, aka “hero’s journey” by Joseph Campbell.
 - f. Understand story elements. “The experience of playing the game is really what allows the story to unfold.” Jeannie Nov.
 - g. Understand storyboarding.
2. Understand the character creation process.
 - a. Understand the elements of a character’s identity.
 - b. Discuss how tone, audience, and purpose impact character identity development.

- c. Discuss the design sequence-rules and regulations for game design.
3. Apply design principles and techniques in the creation of a 2D, digital, and 3D character.
 - a. Understand design principles and techniques for use in planning, designing, and producing a game character.
 - b. Describe sketching as an artistic concept. Explain the basic concepts of sketching as a tool for game design.
 - c. Demonstrate the use of digital drawing tablets as a 2D digital artistic concept.
 - d. Understand 3D.
4. Understand the “rules of play” in game design technology.
 - a. Discuss the relationship between gameplay and game story.
 - b. Demonstrate use of “rules of play” in game design technology.
 - c. Discuss the structure of game “rules.” How should games be structured? How do you create balance within a game?
5. Identify hardware and software related to the game design industry.
 - a. Identify standard hardware platforms available to game players.
 - b. Identify standard software examples for game design and development technology.

Photography for Game Design

1. Demonstrate proficiency in the setup, operation, and troubleshooting of a graphic design computer.
 - a. Demonstrate proficiency in the setup and maintenance of a graphic computer system.
 - b. Manipulate a window by using application software functions and keyboard shortcuts.
 - c. Demonstrate knowledge of an electronic file management system and folder management.
2. Explain photography and graphic digital manipulation elements.
 - a. Identify safety and proper use of equipment related to photography.
 - b. Identify the basic components of a digital camera and photography-related terms.
3. Complete a photography project that meets the needs of an audience.
 - a. Explore image composition and elements of visual design through photography.
 - b. Distinguish file type per job needed.
 - c. Use digital cameras to learn the basics of photography.
 - d. Identify and produce portrait photographs, art photographs (objects in the classroom), and landscape photographs.
 - e. Use photo manipulation to investigate the potential of color enhancement and retouching.
 - f. Compare and contrast the advantages of manipulating a saved copy of an image in various formats.

4. Use photo editing software to create and edit a product for a customer.
 - a. Identify terminology related to the photo editing software.
 - b. Demonstrate how to open and save an image from a digital camera and an image from a scanner in photo editing software.
 - c. Apply the following tools of photo editing software:
 - Histogram
 - Levels
 - Curves
 - Brightness
 - Auto color correction
 - Clone stamp
 - Lasso
 - Magic wand
 - Crop
 - Image
 - Canvas size
 - Transform
 - d. Determine proper resolution for incorporating an image in visual design software.
 - e. Use Photomerge to create panoramic images.

DESIGN VISUALIZATION AND CHARACTER DEVELOPMENT

Artistic Rendering Using Illustration Software

1. Understand the elements of visual design in relation to game design.
 - a. Discuss the visual elements that make up a video game.
 - b. Discuss the basic elements of an image.
 - c. Discuss the element of color and number of colors related to game design.
 - d. Demonstrate the manipulation of images with the use of software commands.
2. Demonstrate the use of illustration software.
 - e. Understand the elements of the illustration software user interface.
 - f. Explore and discuss the tools, features, and preferences within the illustration software.
 - g. Understand the two types of digital images: bitmap and vector, and learn the common image format types.
 - h. Differentiate between the use of value and texture in illustrative art.
 - i. Explore spatial illusions using illustration software.
 - j. Demonstrate mastery of illustration software.
 - k. Save and export completed image(s) into design visualization software.

Design Visualization Software Introduction

1. Interact with the design visualization software effectively and productively with the User Interface.
 - a. Demonstrate the use of User Interface components in the design interface.
 - b. Demonstrate the manipulation and configuration of the viewports.
 - c. Demonstrate the use of menus, toolbars, and command panels in relation to creating and manipulating objects.
 - d. Demonstrate the use of dialog boxes, controls, and keyboard shortcuts.
2. Manage design visualization software file input and output.
 - a. Demonstrate starting a new project and working on an existing project.
 - b. Demonstrate saving a project for the first time and subsequent times.
 - c. Demonstrate the merging of files.
 - d. Demonstrate the importing and exporting of files.
 - e. Demonstrate the linking and attaching of files.
 - f. Explore spatial illusions using illustration software.

Geometry in Design Visualization Software

1. Set an environment for working with design visualization software and create objects using basic geometry.
 - a. Discuss the basic concepts of object creation and manipulation using basic geometry. (DOGeometry in Design VisuaK1)
 - b. Discuss the options for setting preferences and tool options in the user interface in relation to artists and designers.
 - c. Use simple geometry and pivot points in relation to design visualization software.
 - d. Manipulate dialog boxes, controls, and keyboard shortcuts.
 - e. Transform objects using the basic transform commands.
 - f. Demonstrate the use of align tools.
 - g. Demonstrate the making of duplicate objects (cloning).
 - h. Demonstrate object modification by manipulating basic controls in the stack.
 - i. Demonstrate collapsing the stack.
2. Design, create and analyze the visual component of games.
 - a. Demonstrate the use of basic AES tools in relation to design visualization software.
 - b. Distinguish between the basic elements of a shape through modeling.
 - c. Discuss Boolean operations.
 - d. Demonstrate geometry concepts through Boolean and Pro-Boolean operations in design visualization software.

World Design Using Design Visualization Software

1. Identify the fundamental architectural and structural principles of level design in relation to game environments.
 - a. Discuss the history of architecture and how it relates to realistic game environments.
 - b. Discuss the relationship of level design and gameplay--what events occur in each level.
 - c. Demonstrate the similarities and differences between real-world spaces and game spaces.
2. Create, manipulate, and analyze the visual components of the game world.
 - a. Identify and manipulate mapping coordinates.
 - b. Demonstrate how mapping coordinates work and how to manipulate those coordinates using modifiers in the design visualization software.
 - c. Demonstrate the creation of basic materials and the assignment of those materials to objects in a game scene.
 - d. Demonstrate space design by layering multiple texture maps onto a surface to create a composite image using design visualization software.
 - e. Demonstrate the application of sub-maps on similar objects to give unique identity.
3. Manipulate 3-dimensional aspects of the world design by adjusting cameras, lighting, and adding special effects.
 - a. Identify camera perspective and the effects on the game world and gameplay.
 - b. Demonstrate the creation of a camera and the adjustment of the camera angle and perspective.
 - c. Demonstrate the use of different lighting methods.
 - d. Demonstrate the use of particle systems, lens effects, and constraints to create special effects in a game world.

Character Development and Animation

1. Develop an understanding of the principles and history of visual asset generation.
 - a. Discuss the developments in the history of game design and animation.
 - b. Discuss character types and archetypes in relationship to character development.
 - c. Describe ways that characters develop throughout the course of playing a game.
 - d. Discuss character identity through names, verbal and visual character development.
 - e. Discuss the differences in characters from different media.
2. Examine the process of developing visual assets.
 - a. Discuss the importance of time in animation.
 - b. Describe the process of animation and animation techniques.
 - c. Describe the characteristics of reactive animation.

- d. Describe animation curves, path constraints, and alternative pivot points, and how to edit them.
- e. Describe hierarchical animation.

AUDIO AND VIDEO PRODUCTION

Audio Design

1. Research audio history and theory.
 - a. Discuss the components of audio and game design.
 - b. Discuss the history of audio components and their importance in game design.
 - c. Describe the components of a sound system and game audio formats.
2. Understand the functions of audio design fundamentals (creating the atmosphere), and interactive audio for game design.
 - a. Describe how sound can set the mood for a game.
 - b. Create digital sound effects.
 - c. Describe the purpose and primary functions of music in video games.
 - d. Demonstrate music composition.
 - e. Explain voiceovers and how they add personality to game characters.
 - f. Demonstrate the creation of voiceovers, edit, and test voiceovers.
3. Apply fundamentals of 3D audio in order to blend video game audio elements.
 - a. Describe the audio asset assembly, delivery, and the priority process.
 - b. Demonstrate the difference between occlusion and obstruction and the effect on game audio.
 - c. Describe the effect technology has had in the past and may have in the future on game audio.

Video Game Programming

1. Analyze the structure of the C++ language.
 - a. Define C++ programming terms.
 - b. Explain the program development cycle to include input/output, processing, and storage.
 - c. Convert binary code to decimals.
 - d. Construct an algorithm for computer programming technology.
 - e. Demonstrate screen output using the C++ language.
 - f. Classify variable and constants.
 - g. Create, run, and debug an original program to input data, process data, and print a report.
 - h. Create programs that perform calculations using arithmetic operations to include addition, subtraction, multiplication, division, and exponentiation.
 - i. Create programs that include decision, selection, and iteration statements to include IF/THEN statements, Case statements, Do loops and For/Next loops.
 - j. Create programs that use array/table structures.

2. Analyze the purpose, importance, and structure of game engines.
 - a. Identify the core components of game engines relative to game development.
 - b. Discuss the importance of game engines in the game development process.
 - c. Demonstrate object-oriented design and code reuse patterns, and the applications among game developers.
 - d. Develop an understanding of the elements of the game design engine.
 - e. Create game code using a game engine.
3. Develop an understanding of computer networks as they relate to game design technology.
 - a. Define terminology related to computer networks.
 - b. Identify hardware components needed to network two or more computers, such as a NIC card, cables, hubs, switches, and a server.
 - c. Identify the various operating systems for networks such as Novell, Windows NT, Windows XP, Windows Vista, UNIX, Linux, and Mac OS.
 - d. Discuss examples of recognized network topologies.
 - e. Compare network topologies.
 - f. Discuss network protocols related to the game design industry.

Video Game Production

1. Identify the company roles, and team roles and responsibilities related to the game development process.
 - a. Describe the elements of leadership and the qualities necessary to become a successful leader. "Effective team management improves productivity by creating a harmonious, problem-solving environment. Good leaders may not directly influence game design, but they empower their teams to do their best and to be objective about their work." John Hight and Jeannie Novak
 - b. Identify the company roles related to the game development process.
 - c. Identify game development team roles involved in the game development process.
 - d. Explain the phases associated with developing a game from concept to completion.
 - e. Explain the Five-Stage Team Management Model and how it can be used in the game development process.
 - f. Explain and demonstrate how to conduct meetings.
2. Planning, creating, interpreting, and analyzing budgets for game design and development.
 - a. Discuss the elements of a game design budget.
 - b. Plan, construct, interpret, and analyze a game design budget.
3. Apply time and project management skills.
 - a. Explain the components of each stage in the game development process.
 - b. Describe the milestones in project management and how they are accomplished.

4. Communicate with peers, supervisors, and subordinates.
 - a. Explain the communications process.
 - b. Demonstrate active listening skills.
5. Discuss quality assurance and the role it plays in game design.
 - a. Identify the various stages of quality assurance for game development.
 - b. Identify best practices regarding quality assurance.

BUSINESS, EVALUATION, AND DEVELOPMENT

Business of Gaming

1. Explain the importance of audience knowledge and target marketing in game design technology.
 - a. Discuss target markets and how to get a video game sold.
 - b. Explain demographic segregation and how it can be used in a marketing campaign.
 - c. Describe the marketing tools and how each can be used to attract buyers to a product.
 - d. Compare and contrast the areas of the distribution process.
2. Research consumer behavior and publisher relations within the functions of marketing, such as advertising, public relations, sales, and promotions.
 - a. Explain consumer behavior and the influence it can have on the functions of marketing.
 - b. Discuss how game companies and publisher work together to bring a game to market.
 - c. Discuss contracts between game companies and publishers.
3. Research and analyze the economics of the video game industry.
 - a. Discuss the supply chain and how the economy is impacted.
 - b. Investigate cost versus profit for video games.
 - c. Analyze and predict costs and profits for video games.

Video Game Design and Development Seminar and Experience

1. Apply practical video game design mechanics, programming, visual and audio elements, and game production techniques while working in teams.
 - a. Identify the five phases of idea generation.
 - b. Conduct interviews with possible candidates and/or clients.
 - c. Create a “concept” for the video game.
 - d. Create a game inventory.
 - e. Create a menu tree.
 - f. Create a block diagram or chart that represents the elements to be created by specific departments.
 - g. Create a video game.

Game Evaluation

1. Explore and understand video game architecture through testing, defect tracking, technical reviews, and inspections
 - a. Identify the elements of game architecture and the evaluation process.
 - b. Explain the process of bug testing.
 - c. Explain bug fixing.
2. Critically evaluate game design, character development, character animation, sound design, playability, and compatibility.
 - a. Classify the testing priority of elements of game design, character development and animation, sound design, playability, and compatibility.
 - b. Design and develop a video game evaluation plan.
 - c. Demonstrate the process of correcting game problem areas and satisfying quality assurance requirements.

Appendix A: IGDA Standards

CRITICAL GAME STUDIES - Criticism, Analysis & History of electronic and non-electronic games.

VGD.01. Game Criticism

- VGD.01.01 Game studies – ludology, critical theory and research, critical vocabulary
- VGD.01.02 Experience-centered criticism (Player-centered approach) – study of interactivity, function and uses of exploration in virtual worlds, creating player immersion
- VGD.01.03 Consumer-oriented criticism – game advertising, legislative and judicial impact on the game industry, analyzing and understanding the function and current state of the gaming press
- VGD.01.04 Genre analysis – how game genres are defined, history of genres
- VGD.01.05 Auteur studies – authorship issues, branding
- VGD.01.06 Analysis of Game Design – gameplay, narrative, story and plot, character development, art and sound design

VGD.02. Media Studies

- VGD.02.01 Media Research Methods – data collection, ethnography, introduction to mass media, general game research
- VGD.02.02 Core Experiences – game review, criticism

GAMES AND SOCIETY - Understanding how games reflect and construct individuals and groups, as well as how games reflect and are constructed by individuals and groups.

VGD.03. Players and Effects

- VGD.03.01 Gaming Demographics – gender, diversity, child development, patterns of buyers and players, and game-related organizations
- VGD.03.02 The “Cultures” of Gaming – Pop, fan, and mass culture

VGD.04. History

VGD.05. Experience of Play

- VGD.05.01 Historical aspects of the experience of play – history of play, cross-cultural anthropology of play, commonalities and difference of games across nationalities, role of the economy in history of play
- VGD.05.02 Social aspects – social games, “safe spaces”, effects of cheating, stereotypes, ethical and social issues in games
- VGD.05.03 Psychological aspects – theories of intelligence, cognitive theory, games and violence/addiction
- VGD.05.04 Economic aspect - push for larger sales (more sequels of successful products), more licensed products), role of game

quality and supply in the crash of the 80s, changing demographics, new opportunities

VGD.05.05 Human/machine interaction - usability issues, accessibility issues

VGD.06. Construction of Games and Game Technologies

VGD.06.01 Historical aspects of the technologies and institutions that frame the game industry - history of game technologies, game companies, video game litigation and patents

VGD.06.02 Anthropology of the game industry - political and economic context of the game industry, practice of game development, cultural context of game development, game developer "culture", the intersection of gamer culture and game producer culture, the transnational production of games and game technologies

GAME DESIGN - Principles and methodologies behind the rules and play of games.

VGD.07. Conceptual Game Design

VGD.07.01 Understanding the atomic parts of games – game objects (tokens) and game setting, rules, dynamics, play mechanics, goal(s), conflict, theme/color

VGD.07.02 Play Mechanics – game rules, core mechanics, game theory, balance in games

VGD.07.03 Approaches to game design – algorithmic design, player experience approach, world design

VGD.07.04 Boardgame and roleplaying design – wargames, roleplaying games, collectable card games, chance and probability, narrative and flavor

VGD.07.05 Ideas – turning ideas into concept, evaluating game concepts

VGD.07.06 Fun – different kinds of fun, define fun

VGD.07.07 Abstract design elements – positive and negative feedback systems, emergent complexity, simulation and emulation, communication systems

VGD.07.08 Psychological design considerations – operant conditioning, flow states, addiction in gaming, rewards and penalties, difficulty curve, diverse social systems

VGD.07.09 Interface design – theory, human-computer interaction, user task modeling

VGD.07.10 Iterative nature of game design: create, test, change, and repeat

VGD.08. Serious Game Design

VGD.08.01 Uses of games in training, therapeutic and other non-entertainment applications, such as education, instructional design, political statements, artistic medium, and assessment

VGD.09. Practical Game Design

- VGD.09.01 Spatial design – abstract spaces, pacing, narrative, interactive and responsive worlds, goal communication through game design
- VGD.09.02 Task design – action and interaction, puzzles, providing feedback to players
- VGD.09.03 Design integration – melding space and task, integrating art and gameplay
- VGD.09.04 Control schemes – direct/indirect interact manipulation, movement and navigation, item manipulation, inventories
- VGD.09.05 Custom tool use – getting design concepts into a game’s underlying system
- VGD.09.06 Training – teaching how to play the game, consistent challenges and appropriate feedback, keeping track of what players have done
- VGD.09.07 Game tuning – what makes a balanced game, understanding games as dynamic systems, balancing player advancement
- VGD.09.08 Game player analysis – understanding the audience, designing for diverse populations, quality assurance
- VGD.09.09 Play testing – theory, human-computer interaction, user task modeling
- VGD.09.10 Prototyping – creating physical prototypes for turn-based and realtime games, creating digital prototypes for individual systems, rapid prototyping
- VGD.09.11 Game design documentation – writing and maintaining game design document, writing concepts/proposals/rules documents, communicating design ideas, change tracking
- VGD.09.12 Content design – level design

GAME PROGRAMMING - Aspects of traditional computer science and software engineering – modified to address the technical aspects of gaming

VGD.10. Math and Science Techniques

- VGD.10.01 Math - calculus, linear algebra, probability and statistics, geometry
- VGD.10.02 Science - physics, computational mechanics

VGD.11 Style and Design Principles

- VGD.11.01 Coherency
- VGD.11.02 Object oriented programming paradigms
- VGD.11.03 Design patterns – game design patterns

VGD.12 Information Design

- VGD.12.01 Data structures – data architecture, file formats, data organization, data compression
- VGD.12.02 Asset pipelining
- VGD.12.03 Computational geometry
- VGD.12.04 Environmental models, spatial data structures
- VGD.12.05 Database
- VGD.12.06 Machine Architecture
- VGD.12.07 Optimization (CPU and GPU)
- VGD.12.08 Embedded System Development
- VGD.12.09 Configuration Control and Source Control Systems
- VGD.12.10 Software Architecture
- VGD.12.11 Software Engineering

VGD.13 Game Engine Design

- VGD.13.01 Purpose and importance
- VGD.13.02 Architecture and design
- VGD.13.03 Data Pipelines
- VGD.13.04 Methodologies and practices to create stand-alone gaming
- VGD.13.05 Generic and universal issues in programming for 3D engines – graphics libraries, programming object and camera motions, collision detection, special effects

VGD.14 Prototyping

- VGD.14.01 Tools and skills for fast, iterative development
- VGD.14.02 Building flexible systems, configurable by others

VGD.15 Programming teams -- structure and working relationships

- VGD.15.01 Working in interdisciplinary teams
- VGD.15.02 Talking with programmers/artists/designers/producers/etc
- VGD.15.03 Team programming processes and methodologies

VGD.16 Design/Technology synthesis

- VGD.16.01 Supporting player goals and actions
- VGD.16.02 Building intelligent, coherent, consistent, reactive game environments
- VGD.16.03 Platform issues

VGD.17 System architecture for real time game environments and simulations

- VGD.17.01 Concurrent programming techniques
- VGD.17.02 Integration of sub systems (Physics, Collision detection, AI, Input, Render, Scripting)
- VGD.17.03 Incorporating and extending third party systems in a game engine
- VGD.17.04 Resource budgeting (CPU, GPU, memory)

VG.D.18 Computer Architecture

- VG.D.18.01 Structure of a CPU with implications to program design (eg, avoiding branching)
- VG.D.18.02 The memory hierarchy with implications to program design (eg, alignment of data structures in memory, locality of reference)
- VG.D.18.03 Algorithm design considerations for CPU versus GPU implementation

VG.D.19 Tools Construction

- VG.D.19.01 "Tool Development"
- VG.D.19.02 GUI creation
- VG.D.19.03 Tools for multimedia content creation, modification and management
- VG.D.19.04 Custom design tools
- VG.D.19.05 Building flexible systems for non-programmers to use

VG.D.20 Graphics Programming

- VG.D.20.01 Rendering - Transforms, lighting, texturing, clipping, occlusions, transparency, level of detail considerations, using data structures to optimize rendering time
- VG.D.20.02 Animation- forward and inverse kinematics, transform representations, interpolation, techniques, camera animation
- VG.D.20.03 Graphics system design
- VG.D.20.04 Procedural content generation (Textures, Models, etc.)

VG.D.21 Sound / Audio Programming

- VG.D.21.01 Physics of sound and human hearing
- VG.D.21.02 Programming 3D positional sound
- VG.D.21.03 Utilizing Audio Channels
- VG.D.21.04 Audio Prioritization

VG.D.22 Artificial intelligence

- VG.D.22.01 Difference in goals between Game AI and traditional AI
- VG.D.22.02 Path planning, search algorithms
- VG.D.22.03 Agent architectures
- VG.D.22.04 Decision-making systems
- VG.D.22.05 State machine design
- VG.D.22.06 Statistical machine learning

VG.D.23 Networks

- VG.D.23.01 Networking and Server design
- VG.D.23.02 Performance metrics
- VG.D.23.03 Topologies
- VG.D.23.04 Protocols – TCP/IP, UDP, etc
- VG.D.23.05 Security

- VG.D.23.06 Game Servers
- VG.D.23.07 Game Protocol Development
- VG.D.23.08 Available Network Libraries
- VG.D.23.09 Open Source Network Game Case Studies

VG.D.24 Game Logic

- VG.D.24.01 Compilers
- VG.D.24.02 Scripting languages

VG.D.25 Play analysis

- VG.D.25.01 Play testing to monitor player frustration, progress and enjoyment
- VG.D.25.02 Monitoring player state -- gameplay data logging
- VG.D.25.03 Player metrics

VISUAL DESIGN - Designing, creating and analyzing the visual components of games.

VG.D.26 Basic Visual Design

- VG.D.26.01 Art history & theory
- VG.D.26.02 Visual design fundamentals – composition, lighting and color, graphic design and typography
- VG.D.26.03 Fundamentals of drawing
- VG.D.26.04 Painting techniques
- VG.D.26.05 Sculpting
- VG.D.26.06 Anatomy and life drawing
- VG.D.26.07 Physiology and kinesiology

VG.D.27 Non-narrative graphics/Abstraction as expressive tool

VG.D.28 Visual design in an interactive context

VG.D.29 Visual narratives: painting, comics, photography, film

VG.D.30 Motion Graphics

- VG.D.30.01 Animation
- VG.D.30.02 Cinematography
- VG.D.30.03 Camera angles and framing
- VG.D.30.04 Visual narrative / storyboarding
- VG.D.30.05 Filmmaking: framing, types of shots and camera movement, editing
- VG.D.30.06 Kinematics

VG.D.31 Visual Asset Generation

- VG.D.31.01 2d graphics - pixel art
- VG.D.31.02 3d modeling
- VG.D.31.03 Textures
- VG.D.31.04 Interface design

VGD.31.05 Character design - conceptual design, character modeling, character animation

VGD.32 World Design

VGD.32.01 Environmental modeling

VGD.33 Architecture

VGD.33.01 Fundamental principles of architecture

VGD.33.02 History of architecture

VGD.33.03 Fundamental principles of architecture

VGD.33.04 Real-world spaces vs. game spaces

VGD.33.05 Space design

VGD.33.06 Navigation

VGD.33.07 Materials

VGD.34 Working with 3D Hardware

VGD.34.01 Procedural shading

VGD.34.02 Lighting

VGD.34.03 Effects

VGD.35 Game Art (digital based art with game content)

VGD.35.01 Custom tool use – getting game art into a game's engine

VGD.36 Information Visualization

VGD.37 Procedural content

AUDIO DESIGN - Designing and creating sound and sound environments

VGD.38 Audio History & Theory

VGD.39 Basic Technical Skills

VGD.40 Basic Studio Skills

VGD.40.01 Familiarity with hardware and software (e.g., microphones, mixers, outboard gear)

VGD.40.02 Recording, mixing and mastering

VGD.40.03 Studio organization

VGD.41 Audio Programming

VGD.42 Audio Assets

VGD.43 Audio Tools

VGD.44 Audio Design Fundamentals

VGD.44.01 Setting mood, managing tension and resolution

- VGD.44.02 Processing, mixing and controlling sound for aesthetic effect
- VGD.44.03 General workflow for game creation
- VGD.44.04 Audio engine terminology and functionality

VGD.45 Introduction to Interactive Audio

- VGD.45.01 Designing sound for interactivity
- VGD.45.02 Sound effects
- VGD.45.03 Music
- VGD.45.04 Voice recording

VGD.46 Sound Effects

- VGD.46.01 Simulation of sound environments
- VGD.46.02 Ambience versus musicality in soundtracks

VGD.47 Music

- VGD.47.01 Composition
- VGD.47.02 Interactive scoring

VGD.48 3d Audio

- VGD.48.01 Fundamentals of 3D and multi-channel sound
- VGD.48.02 Modeling for effects, echo, room size simulation

INTERACTIVE STORYTELLING - Traditional storytelling and the challenges of interactive narrative

VGD.49 Story in Non-Interactive Media

- VGD.49.01 Literary Theory & Narratology - traditional narrative “act” structure, thinking abstractly and concretely about “story”, traditional narratives (folktales), structuralism/narratology, post-structuralism, post-modern literature
- VGD.49.02 Theatre - performance theory, theorists: Aristotle, Brecht, Artaud, Boal, etc
- VGD.49.03 Story creation - setting: time, place, character actions/motivations/dialogue, events
- VGD.49.04 Discourse – style, voice and point of view, event structure
- VGD.49.05 Characterization in fiction, film and theatre
- VGD.49.06 Introduction to film and literary theory
- VGD.49.07 Theories of game and narrative
- VGD.49.08 Context-setting versus traditional storytelling
- VGD.49.09 Back-story and fictional setting design
- VGD.49.10 Creating compelling characters

VGD.50 Narrative in Interactive Media

- VGD.50.01 Theoretical issues - agency, immersion, interactivity vs. narrative, cybertext, algorithmic storytelling and process intensity, cohesion and “well-formed” narrative
- VGD.50.02 Interactive story in non-computer-based media - role-playing games, oral storytelling, literary examples – Oulipo, Nabakov’s Pale Fire, etc, theatre examples – forum theatre, theatre of the oppressed, etc
- VGD.50.03 Alternating fixed story with interactive game - visual novels (Japanese genre)
- VGD.50.04 Exploratory narratives – hypertext
- VGD.50.05 Branching trees: branching narrative, branching dialogue
- VGD.50.06 Emergent narrative approaches - story generators
- VGD.50.07 Interactive fiction
- VGD.50.08 Collaborative storytelling - web-based collaborative stories, alternative reality games, MUDs, MMOGs

VGD.51 Writing for other media

- VGD.51.01 Fiction-writing
- VGD.51.02 Dramatic writing – screenwriting, playwriting, writing for the radio

VGD.52 Abstract audiovisual narrative

- VGD.52.01 Semiotics and symbology
- VGD.52.02 Creating mood and drama with music and sound

GAME PRODUCTION - Practical challenges of managing the development of games

VGD.53 People management and collaborative development

VGD.54 Budgeting a development project

VGD.55 Where to find industry standard info, industry info – trades, trades from different parts of the industry, other media trades

VGD.56 Typical budgets and budget categories

VGD.57 Team make-up

- VGD.57.01 Job descriptions
- VGD.57.02 Recruiting, training
- VGD.57.03 Balancing talent, experience, budget

VGD.58 The Game Development Lifecycle

- VGD.58.01 Pre-production / Production / Testing
- VGD.58.02 Shipping and maintaining customer loyalty

- VGD.58.03 Different approaches to production process – waterfall/spiral/v-shaped/evolutionary, Scrum/Agile, iterative/incremental, development, rapid prototyping, etc, strengths and weaknesses, issues specific to game development

VGD.59 Workflow

- VGD.59.01 Knowing which tools to use and when
- VGD.59.02 Evaluating and using computer-supported collaborative work tools - bug-tracking systems, wikis, spreadsheets, message boards/forums, databases, version-control
- VGD.59.03 Problem evaluation and investing appropriate resources
- VGD.59.04 Task breakdown - creating a backlog, dropping features

VGD.60 Group dynamics

- VGD.60.01 Team building
- VGD.60.02 Establishing clear roles and clear goals
- VGD.60.03 Realities of development teams
- VGD.60.04 Building effective teams - working as a team to realize a unified gameplay vision, leadership, delegation and responsibility, defining the interfaces between team members

VGD.61 Design and development documentation

- VGD.61.01 Why document?
- VGD.61.02 What should you document?
- VGD.61.03 How much documentation is enough/too much?
- VGD.61.04 Who is the audience for the documentation?
- VGD.61.05 To storyboard or not to storyboard?
- VGD.61.06 Non-text based documentation: using prototypes, physical models, pictures
- VGD.61.07 Design and Development Documents - concept document/proposal, game specifications, design document, story bible, script, art bible, storyboards, technical design document, schedules and business/marketing documents, test plan

VGD.62 Testing

- VGD.62.01 Code review and test harnesses
- VGD.62.02 Designing tests and incorporating feedback from Quality Assurance
- VGD.62.03 Bug fixing, bug databases, creating stable code bases

VGD.63 Scheduling and Time Management

- VGD.63.01 Creating a schedule
- VGD.63.02 Goals of a schedule – milestones
- VGD.63.03 Balancing quality and reality
- VGD.63.04 Working with a schedule, using it to help you ship

- VGD.63.05 Typical schedules
- VGD.63.06 Crunch time issues
- VGD.63.07 Quality of life issues

VGD.64 Communication skills

- VGD.64.01 Rhetoric
- VGD.64.02 Communicating with peers, supervisors and subordinates - communicating clearly in print and in speech, collaboration skills - speaking the same language/speaking across disciplinary divides

VGD.65 Coordinating the efforts of development, quality assurance, sales, marketing, public relations and finance

VGD.66 Localization issues, processes and skills

- VGD.66.01 Writing “around” the game – packaging, player manuals, websites, etc

VGD.67 Product post-mortems

- VGD.67.01 Evaluating decisions, after the fact - design decisions, process decisions, business decisions

VGD.68 Quality Assurance

- VGD.68.01 Planning and QA Plans

VGD.69 Defect Tracking

VGD.70 Technical Reviews and Inspections

VGD.71 Architecture

- VGD.71.01 Software Testing - beta testing, system testing, code review and test harnesses, designing tests and incorporating feedback from quality assurance, bug fixing, bug databases, creating stable code bases
- VGD.71.02 Game Testing

VGD.72 Working with marketing

- VGD.72.01 Marketing plans and schedules
- VGD.72.02 Marketing asset needs

BUSINESS OF GAMING - Economic, legal and policy aspects of games

VGD.73 Game industry economics

- VGD.73.01 Retailers, shelf-space, digital distribution: How audiences currently reach the games

- VGD.73.02 Platform choices – the tradeoffs of developing for consoles, PCs and handheld and mobile devices
- VGD.73.03 Internationalization / globalization of development - offshoring / outsourcing, changing barriers-to-entry (knowledge, technology, manpower), challenges of cultures, distance, time-zones
- VGD.73.04 Distribution channels
- VGD.73.05 Microtransactions, one-time payment, software as a service with monthly payments, free to play with some features available to paying members, etc
- VGD.73.06 Real money transactions in virtual worlds and MMOs
- VGD.73.07 Different delivery method and revenue streams (MS Arcade, PS Home, etc)
- VGD.73.08 Independent vs Publisher/Developer game development
- VGD.73.09 Piracy

VGD.74 Audience

- VGD.74.01 Marketing and sales: How games currently reach an audience
- VGD.74.02 Understanding audiences for different game genres
- VGD.74.03 How to reach and keep given audiences
- VGD.74.04 Consumer behavior and psychology (what do consumers of various sorts and various populations want?)

VGD.75 Publisher/Developer Relationships

- VGD.75.01 The deal - what it covers, how it gets done, what it is likely to say, greenlighting process
- VGD.75.02 Day-to-day: Once signed up, what interactions and processes occur
- VGD.75.03 Milestone review

VGD.76 Intellectual property

- VGD.76.01 Technology and Copyright - key cases, major players
- VGD.76.02 Content
- VGD.76.03 Licenses - acquisition of licenses, use of licenses, working with licensors
- VGD.76.04 Piracy

VGD.77 Patents and the game industry

VGD.78 Contracts

- VGD.78.01 Publisher/developer
- VGD.78.02 Employer/employee
- VGD.78.03 Contractors

VGD.79 Content Regulation

VGD.79.01 Game Ratings and Classification - ESRB (North America), PEGI (Europe), CERO (Japan)

VGD.79.02 Government regulation - North America, Europe / Oceania, Asia

Appendix B: 21st Century Skills Standards

- CS1 Flexibility and Adaptability
- CS2 Initiative and Self-Direction
- CS3 Social and Cross-Cultural Skills
- CS4 Productivity and Accountability
- CS5 Leadership and Responsibility

Today's life and work environments require far more than thinking skills and content knowledge. The ability to navigate the complex life and work environments in the globally competitive information age requires students to pay rigorous attention to developing adequate life and career skills.

CS 1 Flexibility and Adaptability

- Adapting to varied roles and responsibilities
- Working effectively in a climate of ambiguity and changing priorities

CS 2 Initiative and Self-Direction

- Monitoring one's own understanding and learning needs
- Going beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise
- Demonstrating initiative to advance skill levels toward a professional level
- Defining, prioritizing, and completing tasks without direct oversight
- Utilizing time efficiently and managing workload
- Demonstrating commitment to learning as a lifelong process

CS 3 Social and Cross-Cultural Skills

- Working appropriately and productively with others
- Leveraging the collective intelligence of groups when appropriate
- Bridging cultural differences and using differing perspectives to increase innovation and the quality of work

CS 4 Productivity and Accountability

- Setting and meeting high standards and goals for delivering quality work on time
- Demonstrating diligence and a positive work ethic (e.g., being punctual and reliable)

CS 5 Leadership and Responsibility

- Using interpersonal and problem-solving skills to influence and guide others toward a goal
- Leveraging strengths of others to accomplish a common goal
- Demonstrating integrity and ethical behavior
- Acting responsibly with the interests of the larger community in mind

Appendix C: MS Academic Standards

MISSISSIPPI SCIENCE CURRICULUM FRAMEWORKS COMPETENCIES

Aquatic Science

- AQ 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- AQ 2 Develop an understanding of physical and chemical properties of water and aquatic environments.
- AQ 3 Apply an understanding of the diverse organisms found in aquatic environments.
- AQ 4 Draw conclusions about the relationships between human activity and aquatic organisms.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Develop an understanding of physical and chemical properties of water and aquatic environments.

- a. Analyze the physical and chemical properties of water, and justify why it is essential to living organisms. (DOK 1)
- b. Explain the causes and characteristics of tides. (DOK 1)
- c. Research, create diagrams, and summarize principles related to waves and current characteristics and formation. (DOK 2)

- d. Compare and contrast the physical and chemical parameters of dissolved O₂, pH, temperature, salinity, and results obtained through analysis of different water column depths/zones. (DOK 2)
 - e. Investigate the causes and effects of erosion and discuss conclusions. (DOK 2)
 - f. Describe and differentiate among the major geologic features of specific aquatic environments. (DOK 1)
 - Plate tectonics
 - Rise, slope, elevation, and depth
 - Formation of dunes, reefs, barrier/volcanic islands, and coastal/flood plains
 - Watershed formation as it relates to bodies of freshwater
 - g. Compare and contrast the unique abiotic and biotic characteristics of selected aquatic ecosystems. (DOK 2)
 - Barrier island, coral reef, tidal pool, and ocean
 - River, stream, lake, pond, and swamp
 - Bay, sound, estuary, and marsh
- 3. Apply an understanding of the diverse organisms found in aquatic environments.**
- a. Analyze and explain the diversity and interactions among aquatic life. (DOK 3)
 - Adaptations of representative organisms for their aquatic environments
 - Relationship of organisms in food chains/webs within aquatic environments
 - b. Research, calculate, and interpret population data. (DOK 2)
 - c. Research and compare reproductive processes in aquatic organisms. (DOK 2)
 - d. Differentiate among characteristics of planktonic, nektonic, and benthic organisms. (DOK 1)
 - e. Explore the taxonomy of aquatic organisms, and use dichotomous keys to differentiate among the organisms. (DOK 2)
 - f. Research and explain the symbiotic relationships in aquatic ecosystems. (DOK 3)
- 4. Draw conclusions about the relationships between human activity and aquatic organisms.**
- a. Describe the impact of natural and human activity on aquatic ecosystems, and evaluate the effectiveness of various solutions to environmental problems. (DOK 3)
 - Sources of pollution in aquatic environments and methods to reduce the effects of the pollution
 - Effectiveness of a variety of methods of environmental management and stewardship
 - Effects of urbanization on aquatic ecosystems and the effects of continued expansion
 - b. Research and cite evidence of the effects of natural phenomena such as hurricanes, floods, or drought on aquatic habitats and organisms. (DOK 3)
 - c. Discuss the advantages and disadvantages involved in applications of modern technology in aquatic science. (DOK 2)
 - Careers related to aquatic science

- Modern technology within aquatic science (e.g., mariculture and aquaculture)
- Contributions of aquatic technology to industry and government

Biology I

- BIOI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BIOI 2 Describe the biochemical basis of life, and explain how energy flows within and between the living systems.
- BIOI 3 Investigate and evaluate the interaction between living organisms and their environment.
- BIOI 4 Analyze and explain the structures and function of the levels of biological organization.
- BIOI 5 Demonstrate an understanding of the molecular basis of heredity.
- BIOI 6 Demonstrate an understanding of principles that explain the diversity of life and biological evolution.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- d. Formulate questions that can be answered through research and experimental design. (DOK 3)
- e. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2)
- f. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- g. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- h. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- i. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Describe the biochemical basis of life, and explain how energy flows within and between the living systems.

- a. Explain and compare with the use of examples the types of bond formation (e.g., covalent, ionic, hydrogen, etc.) between or among atoms. (DOK 2)

- Subatomic particles and arrangement in atoms
 - Importance of ions in biological processes
 - b. Develop a logical argument defending water as an essential component of living systems (e.g., unique bonding and properties including polarity, high specific heat, surface tension, hydrogen bonding, adhesion, cohesion, and expansion upon freezing). (DOK 2)
 - c. Classify solutions as acidic, basic, or neutral, and relate the significance of the pH scale to an organism's survival (e.g., consequences of having different concentrations of hydrogen and hydroxide ions). (DOK 2)
 - d. Compare and contrast the structure, properties, and principle functions of carbohydrates, lipids, proteins, and nucleic acids in living organisms. (DOK 2)
 - Basic chemical composition of each group
 - Building components of each group (e.g., amino acids, monosaccharides, nucleotides, etc.)
 - Basic functions (e.g., energy, storage, cellular, heredity) of each group
 - e. Examine the life processes to conclude the role enzymes play in regulating biochemical reactions. (DOK 2)
 - Enzyme structure
 - Enzyme function, including enzyme-substrate specificity and factors that affect enzyme function (pH and temperature)
 - f. Describe the role of adenosine triphosphate (ATP) in making energy available to cells. (DOK 1)
 - ATP structure
 - ATP function
 - g. Analyze and explain the biochemical process of photosynthesis and cellular respiration, and draw conclusions about the roles of the reactant and products in each. (DOK 3)
 - Photosynthesis and respiration (reactants and products)
 - Light-dependent reactions and light independent reactions in photosynthesis, including requirements and products of each
 - Aerobic and anaerobic processes in cellular respiration, including products each and energy differences
- 3. Investigate and evaluate the interaction between living organisms and their environment.**
- a. Compare and contrast the characteristics of the world's major biomes (e.g., deserts, tundra, taiga, grassland, temperate forest, tropical rainforest). (DOK 2)
 - Plant and animal species
 - Climate (temperature and rainfall)
 - Adaptations of organisms
 - b. Provide examples to justify the interdependence among environmental elements. (DOK 2)
 - Biotic and abiotic factors in an ecosystem (e.g., water, carbon, oxygen, mold, leaves)

- Energy flow in ecosystems (e.g., energy pyramids and photosynthetic organisms to herbivores, carnivores, and decomposers)
 - Roles of beneficial bacteria
 - Interrelationships of organisms (e.g., cooperation, predation, parasitism, commensalism, symbiosis, and mutualism)
- c. Examine and evaluate the significance of natural events and human activities on major ecosystems (e.g., succession, population growth, technology, loss of genetic diversity, consumption of resources). (DOK 2)
- 4. Analyze and explain the structures and function of the levels of biological organization.**
- a. Differentiate among plant and animal cells and eukaryotic and prokaryotic cells. (DOK 2)
- Functions of all major cell organelles and structures (e.g., nucleus, mitochondrion, rough ER, smooth ER, ribosomes, Golgi bodies, vesicles, lysosomes, vacuoles, microtubules, microfilaments, chloroplast, cytoskeleton, centrioles, nucleolus, chromosomes, nuclear membrane, cell wall, cell membrane [active and passive transport], cytosol)
 - Components of mobility (e.g., cilia, flagella, pseudopodia)
- b. Differentiate between types of cellular reproduction. (DOK 1)
- Main events in the cell cycle and cell mitosis (including differences in plant and animal cell divisions)
 - Binary fission (e.g., budding, vegetative propagation, etc.)
 - Significance of meiosis in sexual reproduction
 - Significance of crossing over
- c. Describe and differentiate among the organizational levels of organisms (e.g., cells, tissues, organs, systems, types of tissues.) (DOK 1)
- d. Explain and describe how plant structures (vascular and nonvascular) and cellular functions are related to the survival of plants (e.g., movement of materials, plant reproduction). (DOK 1)
- 5. Demonstrate an understanding of the molecular basis of heredity.**
- a. Analyze and explain the molecular basis of heredity and the inheritance of traits to successive generations by using the Central Dogma of Molecular Biology. (DOK 3)
- Structures of DNA and RNA
 - Processes of replication, transcription, and translation
 - Messenger RNA codon charts
- b. Utilize Mendel's laws to evaluate the results of monohybrid Punnett squares involving complete dominance, incomplete dominance, codominance, sex linked, and multiple alleles (including outcome percentage of both genotypes and phenotypes.) (DOK 2)
- c. Examine inheritance patterns using current technology (e.g., pedigrees, karyotypes, gel electrophoresis). (DOK 2)
- d. Discuss the characteristics and implications of both chromosomal and gene mutations. (DOK 2)

- Significance of nondisjunction, deletion, substitutions, translocation, frame shift mutation in animals
- Occurrence and significance of genetic disorders such as sickle cell anemia, Tay-Sachs disorder, cystic fibrosis, hemophilia, Down syndrome, color blindness

6. Demonstrate an understanding of principles that explain the diversity of life and biological evolution.

- a. Draw conclusions about how organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships. (DOK 2)
 - Characteristics of the six kingdoms
 - Major levels in the hierarchy of taxa (e.g., kingdom, phylum/division, class, order, family, genus, and species)
 - Body plans (symmetry)
 - Methods of sexual reproduction (e.g., conjugation, fertilization, pollination)
 - Methods of asexual reproduction (e.g., budding, binary fission, regeneration, spore formation)
- b. Critique data (e.g., comparative anatomy, Biogeography, molecular biology, fossil record, etc.) used by scientists (e.g., Redi, Needham, Spallanzani, Pasteur) to develop an understanding of evolutionary processes and patterns. (DOK 3)
- c. Research and summarize the contributions of scientists (including Darwin, Malthus, Wallace, Lamarck, and Lyell) whose work led to the development of the theory of evolution. (DOK 2)
- d. Analyze and explain the roles of natural selection, including the mechanisms of speciation (e.g., mutations, adaptations, geographic isolation) and applications of speciation (e.g., pesticide and antibiotic resistance). (DOK 3)
- e. Differentiate among chemical evolution, organic evolution, and the evolutionary steps along the way to aerobic heterotrophs and photosynthetic autotrophs. (DOK 2)

Biology II

- BIOII 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BIOII 2 Describe and contrast the structures, functions, and chemical processes of the cell.
- BIOII 3 Investigate and discuss the molecular basis of heredity.
- BIOII 4 Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.
- BIOII 5 Develop an understanding of organism classification.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic. (DOK 3)
 - b. Clarify research questions and design laboratory investigations. (DOK 3)
 - c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
 - e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
 - f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
 - g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)
- 2. Describe and contrast the structures, functions, and chemical processes of the cell.**
- a. Relate the structure and function of a selectively permeable membrane to its role in diffusion and osmosis. (DOK 2)
 - b. Summarize how cell regulation controls and coordinates cell growth and division. (DOK 2)
 - c. Analyze and describe the function of enzymes in biochemical reactions. (DOK 2)
 - The impact of enzymatic reactions on biochemical processes
 - Factors that affect enzyme function (e.g., pH, concentration, temperature, etc.)
 - d. Differentiate between photosynthesis and cellular respiration. (DOK 2)
 - Cellular sites and major pathways of anaerobic and aerobic respiration (with reactants, products, and ATP per monosaccharide)
 - Cellular respiration with respect to the sites at which they take place, the reactions involved, and the energy input and output in each stage (e.g., glycolysis, Krebs cycle, electron transport chain)
 - Pigments, absorption, reflection of light, and light-dependent and light-independent reactions of photosynthesis
 - Oxidation and reduction reactions
- 3. Investigate and discuss the molecular basis of heredity.**
- a. Explain how the process of meiosis clarifies the mechanism underlying Mendel's conclusions about segregation and independent assortment on a molecular level. (DOK 1)
 - b. Research and explain how major discoveries led to the determination of DNA structure. (DOK 2)
 - c. Relate gene expression (e.g., replication, transcription, translation) to protein structure and function. (DOK 2)
 - Translation of a messenger RNA strand into a protein

- Processing by organelles so that the protein is appropriately packaged, labeled, and eventually exported by the cell
 - Messenger RNA codon charts to determine the effects of different types of mutations on amino acid sequence and protein structure (e.g., sickle cell anemia resulting from base substitution mutation)
 - Gene expression regulated in organisms so that specific proteins are synthesized only when they are needed by the cell (e.g., allowing cell specialization)
- d. Assess the potential implications of DNA technology with respect to its impact on society. (DOK 3)
- Modern DNA technologies (e.g., polymerase chain reaction (PCR), gene splicing, gel electrophoresis, transformation, recombinant DNA) in agriculture, medicine, and forensics
- e. Develop a logical argument defending or refuting bioethical issues arising from applications of genetic technology (e.g., the human genome project, cloning, gene therapy, stem cell research). (DOK 3)
4. **Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.**
- a. Explain the history of life on earth, and infer how geological changes provide opportunities and constraints for biological evolution. (DOK 2)
- Main periods of the geologic timetable of earth's history
 - Roles of catastrophic and gradualistic processes in shaping planet Earth
- b. Provide support for the argument based upon evidence from anatomy, embryology, biochemistry, and paleontology that organisms descended with modification from common ancestry. (DOK 2)
- c. Identify and provide supporting evidence for the evolutionary relationships among various organisms using phylogenetic trees and cladograms. (DOK 2)
- d. Formulate a scientific explanation based on fossil records of ancient life-forms, and describe how new species could originate as a result of geological isolation and reproductive isolation. (DOK 2)
- e. Compare and contrast the basic types of selection (e.g., disruptive, stabilizing, directional, etc.). (DOK 2)
- f. Cite examples to justify behaviors that have evolved through natural selection (e.g., migration, parental care, use of tools, etc.). (DOK 1)
- g. Research and explain the contributions of 19th century scientists (e.g., Malthus, Wallace, Lyell, and Darwin) on the formulation of ideas about evolution. (DOK 2)
- h. Develop a logical argument describing ways in which the influences of 20th century science have impacted the development of ideas about evolution (e.g., synthetic theory of evolution, molecular biology). (DOK 3)
- i. Analyze changes in an ecosystem resulting from natural causes (succession), changes in climate, human activity (pollution and recycling), or introduction of nonnative species. (DOK 2)
5. **Develop an understanding of organism classification.**

- a. Classify organisms according to traditional Linnaean classification characteristics (e.g., cell structure, biochemistry, anatomy, fossil record, methods of reproduction) and the cladistic approach. (DOK 2)
- b. Categorize organisms according to the characteristics that distinguish them as Bacteria, Archaea, or Eucarya. (DOK 1)
 - Bacteria, fungi, and protists
 - Characteristics of invertebrates (e.g., habitat, reproduction, body plan, locomotion) as related to phyla (e.g., Porifera, Cnidarians, Nematoda, Annelida, Platyhelminthes, and Arthropoda) and classes (e.g., Insecta, Crustacea, Arachnida, Mollusca, Echinodermata)
 - Characteristics of vertebrates (e.g., habitat, reproduction, body plan, locomotion) as related to classes (e.g., Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, Mammalia)
 - Nomenclature of various types of plants (e.g., Bryophyta, Tracheophyta, Gymnospermae, Angiospermae, Monocotyledonae, Dicotyledonae, vascular plants, nonvascular plants)

Botany

- BO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BO 2 Distinguish among the characteristics of botanical organization, structure, and function.
- BO 3 Demonstrate an understanding of plant reproduction.
- BO 4 Draw conclusions about the factors that affect the adaptation and survival of plants.
- BO 5 Relate an understanding of plant genetics to its uses in modern living.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)

- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
- 2. Distinguish among the characteristics of botanical organization, structure, and function.**
- a. Relate plant cell structures to their functions (e.g., major organelles, cell wall components, photosynthetic chemical reactions, plant pigments, plant tissues, roots, stems, leaves, flowers). (DOK 1)
 - b. Differentiate the characteristics found in various plant divisions. (DOK 2)
 - Differences and similarities of nonvascular plants
 - Characteristics of seed-bearing and non-seed bearing vascular plants relative to taxonomy
 - Major vegetative structures and their modifications in angiosperms and gymnosperms
 - c. Compare and contrast leaf modifications of gymnosperms and angiosperms (e.g., needles, overlapping scales, simple leaves, compound leaves, evergreen trees, and deciduous trees). (DOK 2)
 - d. Apply the modern classification scheme utilized in naming plants to identify plant specimens. (DOK 2)
 - Classification scheme used in botany
 - Classification of native Mississippi plants
 - e. Use inquiry to investigate and discuss the physical and chemical processes of plants. (DOK 3)
 - Relationships among photosynthesis, cellular respiration, and translocation
 - Importance of soil type and soil profiles to plant survival
 - Mechanism of water movement in plants
 - Effects of environmental conditions for plant survival
 - Tropic responses of a plant organ to a given stimulus
- 3. Demonstrate an understanding of plant reproduction.**
- a. Compare and contrast reproductive structures (e.g., cones, flowers). (DOK 2)
 - b. Differentiate among the vegetative organs of monocots, herbaceous dicots, and woody dicots. (DOK 1)
 - c. Differentiate between the structures and processes of sexual and asexual reproduction in plants. (DOK 1)
 - Reproductive structures, their modifications, and the mechanisms involved in plant reproduction
 - Functions of flower parts, seeds, cones
 - Spore production in bryophytes and ferns
 - d. Explain and provide examples of the concept of alternation of generations and its examples. (DOK 2)
 - e. Categorize types of fruits and methods of seed distribution in plants. (DOK 1)

- f. Research and compare various methods of plant propagation. (DOK 2)
- 4. Draw conclusions about the factors that affect the adaptation and survival of plants.**
- a. List and assess several adaptations of plants to survive in a given biome. (DOK 2)
- b. Design and conduct an experiment to determine the effects of environmental factors on photosynthesis. (DOK 3)
- c. Explain how natural selection and the evolutionary consequences (e.g., adaptation or extinction) support scientific explanations for similarities of ancient life-forms in the fossil record and molecular similarities present in living organisms. (DOK 2)
- d. Research factors that might influence or alter plant stability, and propose actions that may reduce the negative impacts of human activity. (DOK 2)
- 5. Relate an understanding of plant genetics to its uses in modern living.**
- a. Research, prepare, and present a position relating to issues surrounding the current botanical trends involving biotechnology. (DOK 3)
- b. Apply an understanding of the principles of plant genetics to analyze monohybrid and dihybrid crosses, and predict the potential effects the crosses might have on agronomy and agriculture. (DOK 3)
- c. Discuss the effects of genetic engineering of plants on society. (DOK 2)
- d. Describe the chemical compounds extracted from plants, their economical importance, and the impact on humans. (DOK 3)
- Plant extracts, their function, and origin
 - Impact of the timber industry on local and national economy

Chemistry I

- CHI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- CHI 2 Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.
- CHI 3 Develop an understanding of the periodic table.
- CHI 4. Analyze the relationship between microscopic and macroscopic models of matter.
- CHI 5 Compare factors associated with acid/base and oxidation/reduction reactions.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)

- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
 - e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
 - f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
 - g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)
- 2. Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.**
- a. Describe and classify matter based on physical and chemical properties and interactions between molecules or atoms. (DOK 1)
 - Physical properties (e.g., melting points, densities, boiling points) of a variety of substances
 - Substances and mixtures
 - Three states of matter in terms of internal energy, molecular motion, and the phase transitions between them
 - b. Research and explain crucial contributions and critical experiments of Dalton, Thomson, Rutherford, Bohr, de Broglie, and Schrödinger, and describe how each discovery contributed to the current model of atomic and nuclear structure. (DOK 2)
 - c. Develop a model of atomic and nuclear structure based on theory and knowledge of fundamental particles. (DOK 2)
 - Properties and interactions of the three fundamental particles of the atom
 - Laws of conservation of mass, constant composition, definite proportions, and multiple proportions
 - d. Write appropriate equations for nuclear decay reactions, describe how the nucleus changes during these reactions, and compare the resulting radiation with regard to penetrating ability. (DOK 1)
 - Three major types of radioactive decay (e.g., alpha, beta, gamma) and the properties of the emissions (e.g., composition, mass, charge, penetrating power)
 - The concept of half-life for a radioactive isotope (e.g., carbon-14 dating) based on the principle that the decay of any individual atom is a random process
 - e. Compare the properties of compounds according to their type of bonding. (DOK 1)
 - Covalent, ionic, and metallic bonding
 - Polar and nonpolar covalent bonding
 - Valence electrons and bonding atoms

- f. Compare different types of intermolecular forces, and explain the relationship between intermolecular forces, boiling points, and vapor pressure when comparing differences in properties of pure substances. (DOK 1)
 - g. Develop a three-dimensional model of molecular structure. (DOK 2)
 - Lewis dot structures for simple molecules and ionic compounds
 - Valence shell electron pair repulsion theory (VSEPR)
- 3. Develop an understanding of the periodic table.**
- a. Calculate the number of protons, neutrons, and electrons in individual isotopes using atomic numbers and mass numbers, write electron configurations of elements and ions following the Aufbau principle, and balance equations representing nuclear reactions. (DOK 1)
 - b. Analyze patterns and trends in the organization of elements in the periodic table, and compare their relationship to position in the periodic table. (DOK 2)
 - Atomic number, atomic mass, mass number, and number of protons, electrons, and neutrons in isotopes of elements
 - Average atomic mass calculations
 - Chemical characteristics of each region
 - Periodic properties (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius)
 - c. Classify chemical reactions by type. (DOK 2)
 - Single displacement, double displacement, synthesis (combination), decomposition, disproportionation, combustion, or precipitation
 - Products (given reactants) or reactants (given products) for each reaction type
 - Solubility rules for precipitation reactions and the activity series for single and double displacement reactions
 - d. Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)
 - Difference between chemical reactions and chemical equations
 - Formulas and calculations of the molecular (molar) masses
 - Empirical formula given the percent composition of elements
 - Molecular formula given the empirical formula and molar mass
- 4. Analyze the relationship between microscopic and macroscopic models of matter.**
- a. Calculate the number of protons, neutrons, and electrons in individual isotopes using atomic numbers and mass numbers, write electron configurations of elements and ions following the Aufbau principle, and balance equations representing nuclear reactions. (DOK 1)
 - b. Analyze patterns and trends in the organization of elements in the periodic table, and compare their relationship to position in the periodic table. (DOK 2)
 - Atomic number, atomic mass, mass number, and number of protons, electrons, and neutrons in isotopes of elements
 - Average atomic mass calculations
 - Chemical characteristics of each region

- Periodic properties (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius)
 - c. Classify chemical reactions by type. (DOK 2)
 - Single displacement, double displacement, synthesis (combination), decomposition, disproportionation, combustion, or precipitation
 - Products (given reactants) or reactants (given products) for each reaction type
 - Solubility rules for precipitation reactions and the activity series for single and double displacement reactions
 - d. Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)
 - Difference between chemical reactions and chemical equations
 - Formulas and calculations of the molecular (molar) masses
 - Empirical formula given the percent composition of elements
 - Molecular formula given the empirical formula and molar mass
- 5. Compare factors associated with acid/base and oxidation/reduction reactions.**
- a. Analyze and explain acid/base reactions. (DOK 2)
 - Properties of acids and bases, including how they affect indicators and the relative pH of the solution
 - Formation of acidic and basic solutions
 - Definition of pH in terms of the hydronium ion concentration and the hydroxide ion concentration
 - The pH or pOH from the hydrogen ion or hydroxide ion concentrations of solution
 - How a buffer works and examples of buffer solutions
 - b. Classify species in aqueous solutions according to the Arrhenius and Bronsted-Lowry definitions respectively, and predict products for aqueous neutralization reactions. (DOK 2)
 - c. Analyze a reduction/oxidation reaction (REDOX) to assign oxidation numbers (states) to reaction species, and identify the species oxidized and reduced, the oxidizing agent, and reducing agent. (DOK 2)

Organic Chemistry

- ORGC 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ORGC 2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
- ORGC 3 Discuss the versatility of polymers and the diverse application of organic chemicals.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results, and make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Demonstrate an understanding of the properties, structure, and function of organic compounds.

- a. Apply International Union of Pure and Applied Chemistry (IUPAC) nomenclature, and differentiate the structure of aliphatic, aromatic, and cyclic hydrocarbon compounds. (DOK 1)
 - Structures of hydrocarbon compounds
 - Isomerism in hydrocarbon compounds
- b. Relate structure to physical and chemical properties of hydrocarbon. (DOK 1)
- c. Apply principles of geometry and hybridization to organic molecules. (DOK 2)
 - Lewis structures for organic molecules
 - Bond angles
 - Hybridization (as it applies to organic molecules)
- d. Write, complete, and classify common reactions for aliphatic, aromatic, and cyclic hydrocarbons. (DOK 1)
- e. Construct, solve, and explain equations representing combustion reactions, substitution reactions, dehydrogenation reactions, and addition reactions. (DOK 2)
- f. Classify functional groups (e.g., alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides, and nitriles) by their structure and properties. (DOK 2)
 - Structural formulas from functional group names and vice versa

- Chemical and physical properties of compounds containing functional groups
 - Equations representing the transformation of one functional group into another
- 3. Discuss the versatility of polymers and the diverse application of organic chemicals.**
- a. Describe and classify the synthesis, properties, and uses of polymers. (DOK 2)
 - Common polymers
 - Synthesis of polymers from monomers by addition or condensation
 - Condensations of plastics according to their commercial types
 - Elasticity and other polymer properties
 - b. Develop a logical argument supporting the use of organic chemicals and their application in industry, drug manufacture, and biological chemistry. (DOK 1)
 - Common uses of polymers and organic compounds in medicine, drugs, and personal care products
 - Compounds that have the property to dye materials
 - Petrochemical production
 - Biologically active compounds in terms of functional group substrate interaction
 - c. Research and summarize the diversity, applications, and economics of industrial chemicals (solvents, coatings, surfactants, etc.). (DOK 3)

Earth and Space Science

- E1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- E2 Develop an understanding of the history and evolution of the universe and earth.
- E3 Discuss factors that are used to explain the geological history of earth.
- E4 Demonstrate an understanding of earth systems relating to weather and climate.
- E5 Apply an understanding of ecological factors to explain relationships between earth systems.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers.
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)

- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
- 2. Develop an understanding of the history and evolution of the universe and earth.**
- a. Summarize the origin and evolution of the universe. (DOK 2)
 - Big bang theory
 - Microwave background radiation
 - The Hubble constant
 - Evidence of the existence of dark matter and dark energy in the universe and the history of the universe
 - b. Differentiate methods used to measure space distances, including astronomical unit, light-year, stellar parallax, Cepheid variables, and the red shift. (DOK 1)
 - c. Interpret how gravitational attraction played a role in the formation of the planetary bodies and how the fusion of hydrogen and other processes in “ordinary” stars and supernovae lead to the formation of all other elements. (DOK 2)
 - d. Summarize the early evolution of the earth, including the formation of Earth’s solid layers (e.g., core, mantle, and crust), the distribution of major elements, the origin of internal heat sources, and the initiation of plate tectonics. (DOK 2)
 - How the decay of radioactive isotopes is used to determine the age of rocks, earth, and the solar system
 - How Earth acquired its initial oceans and atmosphere
- 3. Discuss factors which are used to explain the geological history of earth.**
- a. Develop an understanding of how plate tectonics create certain geological features, materials, and hazards. (DOK 1)
 - Plate tectonic boundaries (e.g., divergent, convergent, and transform)
 - Modern and ancient geological features to each kind of plate tectonic boundary
 - Production of particular groups of igneous and metamorphic rocks and mineral resources
 - Sedimentary basins created and destroyed through time
 - b. Compare and contrast types of mineral deposits/groups (e.g., oxides, carbonates, halides, sulfides, sulfates, silicates, phosphates). (DOK 2)
 - c. Categorize minerals and rocks by determining their physical and/or chemical characteristics. (DOK 2)
 - d. Justify the causes of certain geological hazards (e.g., earthquakes, volcanoes, tsunamis) to their effects on specific plate tectonic locations. (DOK 2)
 - e. Interpret and explain how rock relationships and fossils are used to reconstruct the geologic history of the earth. (DOK 2)

- f. Apply principles of relative age (e.g., superposition, original horizontality, crosscutting relations, and original lateral continuity) to support an opinion related to earth's geological history. (DOK 3)
 - Types of unconformity (e.g., disconformity, angular unconformity, nonconformity)
 - Geological timetable
 - g. Apply the principle of uniformitarianism to relate sedimentary rock associations and their fossils to the environments in which the rocks were deposited. (DOK 2)
 - h. Compare and contrast the relative and absolute dating methods (e.g., the principle of fossil succession, radiometric dating, and paleomagnetism) for determining the age of the earth. (DOK 1)
- 4. Demonstrate an understanding of earth systems relating to weather and climate.**
- a. Explain the interaction of earth systems that affect weather and climate. (DOK 1)
 - Latitudinal variations in solar heating
 - The effects of Coriolis forces on ocean currents, cyclones, anticyclones, ocean currents, topography, and air masses (e.g., warm fronts, cold fronts, stationary fronts, and occluded fronts).
 - b. Interpret the patterns in temperature and precipitation that produce the climate regions on earth, and relate them to the hazards associated with extreme weather events and climate change (e.g., hurricanes, tornadoes, El Niño/La Niña, global warming). (DOK 2)
 - c. Justify how changes in global climate and variation in earth/sun relationships contribute to natural and anthropogenic (human-caused) modification of atmospheric composition. (DOK 2)
 - d. Summarize how past and present actions of ice, wind, and water contributed to the types and distributions of erosional and depositional features in landscapes. (DOK 1)
 - e. Research and explain how external forces affect earth's topography. (DOK 2)
 - How surface water and groundwater act as the major agents of physical and chemical weathering
 - How soil results from weathering and biological processes
 - Processes and hazards associated with both sudden and gradual mass wasting
- 5. Apply an understanding of ecological factors to explain relationships between earth systems.**
- a. Draw conclusions about how life on earth shapes earth systems and responds to the interaction of earth systems (lithosphere, hydrosphere, atmosphere, and biosphere). (DOK 3)
 - Nature and distribution of life on earth, including humans, to the chemistry and availability of water
 - Distribution of biomes (e.g., terrestrial, freshwater, and marine) to climate regions through time
 - Geochemical and ecological processes (e.g., rock, hydrologic, carbon, nitrogen) that interact through time to cycle matter and energy and how

- human activity alters the rates of these processes (e.g., fossil fuel formation and combustion, damming and channeling of rivers)
- b. Interpret the record of shared ancestry (fossils), evolution, and extinction as related to natural selection. (DOK 2)
 - c. Identify the cause and effect relationships of the evolutionary innovations that most profoundly shaped earth systems. (DOK 1)
 - Photosynthesis and the atmosphere
 - Multicellular animals and marine environments
 - Land plants and terrestrial environments
 - d. Cite evidence about how dramatic changes in earth's atmosphere influenced the evolution of life. (DOK 1)

Environmental Science

- ES 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ES 2 Develop an understanding of the relationship of ecological factors that affect an ecosystem.
- ES 3 Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK3)

2. Develop an understanding of the relationship of ecological factors that affect an ecosystem.

- a. Compare ways in which the three layers of the biosphere change over time and their influence on an ecosystem's ability to support life. (DOK 2)
- b. Explain the flow of matter and energy in ecosystems. (DOK 2)
 - Interactions between biotic and abiotic factors
 - Indigenous plants and animals and their roles in various ecosystems
 - Biogeochemical cycles within the environment
- c. Predict the impact of the introduction, removal, and reintroduction of an organism on an ecosystem. (DOK 3)
- d. Develop a logical argument explaining the relationships and changes within an ecosystem. (DOK 2)
 - How a species adapts to its niche
 - Process of primary and secondary succession and its effects on a population
 - How changes in the environment might affect organisms
- e. Explain the causes and effects of changes in population dynamics (e.g., natural selection, exponential growth, predator/prey relationships) to carrying capacity and limiting factors. (DOK 2)
- f. Research and explain how habitat destruction leads to the loss of biodiversity. (DOK 2)
- g. Compare and contrast the major biomes of the world's ecosystems, including location, climate, adaptations and diversity. (DOK 1)

3. Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.

- a. Summarize the effects of human activities on resources in the local environments. (DOK 2)
 - Sources, uses, quality, and conservation of water
 - Renewable and nonrenewable resources
 - Effects of pollution (e.g., water, noise, air, etc.) on the ecosystem
- b. Research and evaluate the impacts of human activity and technology on the lithosphere, hydrosphere, and atmosphere, and develop a logical argument to support how communities restore ecosystems. (DOK 3)
- c. Research and evaluate the use of renewable and nonrenewable resources, and critique efforts to conserve natural resources and reduce global warming in the United States including (but not limited) to Mississippi. (DOK 3)

Genetics

- G 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- G 2 Analyze the structure and function of the cell and cellular organelles.
- G 3 Apply the principles of heredity to demonstrate genetic understandings.

- 1. Use critical thinking and scientific problem solving in designing and performing biological research and experimentation. (L, P, E)**
 - a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
 - b. Clarify research questions and design laboratory investigations. (DOK 3)
 - c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for pie, bar, and line graphs) to draw conclusions and make inferences. (DOK 3)
 - e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
 - f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
 - g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)
- 2. Review the structure and function of the cell as it applies to genetics. (L)**
 - a. Cite evidence to illustrate how the structure and function of cells are involved in the maintenance of life. (DOK 2)
 - b. Describe how organic components are integral to biochemical processes. (DOK 2)
 - c. Differentiate among the processes by which plants and animals reproduce. (DOK 1)
 - Cell cycle and mitosis
 - Meiosis, spermatogenesis, and oogenesis
 - d. Explain the significance of the discovery of nucleic acids. (DOK 1)
 - e. Analyze and explain the structure and function of DNA and RNA in replication, transcription, translation and DNA repair. (DOK 2)
 - f. Cite examples to compare the consequences of the different types of mutations. (DOK 1)
 - g. Draw conclusions about the importance and potential impacts of the process of gene transfer used in biotechnology. (DOK 3)
- 3. Analyze the structure and function of DNA and RNA molecules. (L, P)**
 - a. Cite evidence that supports the significance of Mendel's concept of "particulate inheritance" to explain the understanding of heredity. (DOK 1)
 - b. Apply classical genetics principles to solve basic genetic problems. (DOK 2)
 - Genes and alleles, dominance, recessiveness, the laws of segregation, and independent assortment
 - Inheritance of autosomal and sex-linked traits
 - Inheritance of traits influenced by multiple alleles and traits with polygenetic inheritance
 - Chromosomal theory of inheritance

- c. Apply population genetic concepts to summarize variability of multicellular organisms. (DOK 2)
 - Genetic variability
 - Hardy-Weinberg formula
 - Migration and genetic drift
 - Natural selection in humans
- d. Distinguish and explain the applications of various tools and techniques used in DNA manipulation. (DOK 1)
 - Steps in genetic engineering experiments
 - Use of restriction enzymes
 - Role of vectors in genetic research
 - Use of transformation techniques
- e. Research and present a justifiable explanation the practical uses of biotechnology (e.g., chromosome mapping, karyotyping, and pedigrees). (DOK 2)
- f. Develop and present a scientifically-based logical argument for or against moral and ethical issues related to genetic engineering. (DOK 3)
- g. Research genomics (human and other organisms), and predict benefits and medical advances that may result from the use of genome projects. (DOK 2)

Geology

- GE1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- GE2 Develop an understanding of plate tectonics and geochemical and ecological processes that affect earth.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)

- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Develop an understanding of plate tectonics and geochemical and ecological processes that affect earth.

- a. Differentiate the components of the earth's atmosphere and lithosphere. (DOK 1)
- b. Research and summarize explanations of how earth acquired its initial atmosphere and oceans. (DOK 2)
- c. Compare the causes and effects of internal and external components that shape earth's topography. (DOK 2)
 - Physical weathering (e.g., atmospheric, glacial, etc.)
 - Chemical weathering agents (e.g., acid precipitation, carbon dioxide, oxygen, water, etc.)
- d. Develop an understanding of how plate tectonics create certain geologic features, materials, and hazards. (DOK 2)
 - Types of crustal movements and the resulting landforms (e.g., seafloor spreading, paleomagnetic measurements, and orogenesis)
 - Processes that create earthquakes and volcanoes
 - Asthenosphere
- e. Summarize the theories of plate development and continental drift, and describe the causes and effects involved in each. (DOK 2)
- f. Develop a logical argument to explain how geochemical and ecological processes (e.g., rock, hydrologic, carbon, nitrogen) interact through time to cycle matter and energy and how human activity alters the rates of these processes (e.g., fossil fuel formation and combustion, damming, and channeling of rivers). (DOK 2)
- g. Interpret how the earth's geological time scale relates to geological history, landforms, and life-forms. (DOK 2)
- h. Research and describe different techniques for determining relative and absolute age of the earth (e.g., index of fossil layers, superposition, radiometric dating, etc.) (DOK 1)
- i. Summarize the geological activity of the New Madrid fault line, and compare and contrast it to geological activity in other parts of the world. (DOK 2)
- j. Identify and differentiate the major geological features in Mississippi (e.g., Delta, Coastal Areas, etc.). (DOK 1)
- k. Evaluate an emergency preparedness plan for natural disasters associated with crustal movement. (DOK 3)

Physical Science

- PS 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- PS 2 Describe and explain how forces affect motion.

- PS 3 Demonstrate an understanding of general properties and characteristics of waves.
- PS 4 Develop an understanding of the atom.
- PS 5 Investigate and apply principles of physical and chemical changes in matter.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use appropriate laboratory safety symbols and procedures to design and conduct a scientific investigation. (DOK 2)
 - Safety symbols and safety rules in all laboratory activities
 - Proper use and care of the compound light microscope
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Identify questions that can be answered through scientific investigations. (DOK 3)
- c. Identify and apply components of scientific methods in classroom investigations. (DOK 3)
 - Predicting, gathering data, drawing conclusions
 - Recording outcomes and organizing data from a variety of sources (e.g., scientific articles, magazines, student experiments, etc.)
 - Critically analyzing current investigations/problems using periodicals and scientific scenarios
- d. Interpret and generate graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures and data to draw conclusions about the validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Communicate effectively to present and explain scientific results, using appropriate terminology and graphics. (DOK 3)

2. Describe and explain how forces affect motion.

- a. Demonstrate and explain the basic principles of Newton's three laws of motion including calculations of acceleration, force, and momentum. (DOK 2)
 - Inertia and distance-time graphs to determine average speed
 - Net force (accounting for gravity, friction, and air resistance) and the resulting motion of objects
 - Effects of the gravitational force on objects on Earth and effects on planetary and lunar motion
 - Simple harmonic motion (oscillation)
- b. Explain the connection between force, work, and energy. (DOK 2)
 - Force exerted over a distance (results in work done)
 - Force-distance graph (to determine work)
 - Network on an object that contributes to change in kinetic energy (work-to-energy theorem)

- c. Describe (with supporting details and diagrams) how the kinetic energy of an object can be converted into potential energy (the energy of position) and how energy is transferred or transformed (conservation of energy). (DOK 2)
 - d. Draw and assess conclusions about charges and electric current. (DOK 2)
 - Static/current electricity and direct current/alternating current
 - Elements in an electric circuit that are in series or parallel
 - Conductors and insulators
 - Relationship between current flowing through a resistor and voltage flowing across a resistor
 - e. Cite evidence and explain the application of electric currents and magnetic fields as they relate to their use in everyday living (e.g., the application of fields in motors and generators and the concept of electric current using Ohm's Law). (DOK 2)
- 3. Demonstrate an understanding of general properties and characteristics of waves.**
- a. Differentiate among transverse, longitudinal, and surface waves as they propagate through a medium (e.g., string, air, water, steel beam). (DOK 1)
 - b. Compare properties of waves (e.g., superposition, interference, refraction, reflection, diffraction, Doppler effect), and explain the connection among the quantities (e.g., wavelength, frequency, period, amplitude, and velocity). (DOK 2)
 - c. Classify the electromagnetic spectrum's regions according to frequency and/or wavelength, and draw conclusions about their impact on life. (DOK 2)
 - The emission of light by electrons when moving from higher to lower levels
 - Energy (photons as quanta of light)
 - Additive and subtractive properties of colors
 - Relationship of visible light to the color spectrum
 - d. Explain how sound intensity is measured and its relationship to the decibel scale. (DOK 1)
- 4. Develop an understanding of the atom.**
- a. Cite evidence to summarize the atomic theory. (DOK 1)
 - Models for atoms
 - Hund's rule and Aufbau process to specify the electron configuration of elements
 - Building blocks of matter (e.g., proton, neutron, and electron) and elementary particles (e.g., positron, mesons, neutrinos, etc.)
 - Atomic orbitals (s, p, d, f) and their basic shapes
 - b. Explain the difference between chemical and physical changes, and demonstrate how these changes can be used to separate mixtures and compounds into their components. (DOK 2)
 - c. Research the history of the periodic table of the elements, and summarize the contributions that led to the atomic theory. (DOK 2)
 - Contributions of scientists (e.g., John Dalton, J.J. Thomson, Ernest Rutherford, Newton, Einstein, Neils, Bohr, Louis de Broglie, Erwin Schrödinger, etc.)
 - Technology (e.g., X-rays, cathode-ray tubes, spectrosopes)

- Experiments (e.g., gold-foil, cathode-ray, etc.)
- d. Utilize the periodic table to predict and explain patterns and draw conclusions about the structure, properties, and organization of matter. (DOK 2)
 - Atomic composition and valence electron configuration (e.g., atomic number, mass number of protons, neutrons, electrons, isotopes, and ions)
 - Periodic trends using the periodic table (e.g., valence, reactivity, atomic radius)
 - Average atomic mass from isotopic abundance
 - Solids, liquids, and gases
 - Periodic properties of elements (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius) and how they relate to position in the periodic table
- 5. **Investigate and apply principles of physical and chemical changes in matter.**
 - a. Write chemical formulas for compounds comprising monatomic and polyatomic ions. (DOK 1)
 - b. Balance chemical equations. (DOK 2)
 - c. Classify types of chemical reactions (e, g., composition, decomposition, single displacement, double displacement, combustion, acid/base reactions). (DOK 2)

Physics I

- PHYI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- PHYI 2 Develop an understanding of concepts related to forces and motion.
- PHYI 3 Develop an understanding of concepts related to work and energy.
- PHYI 4 Discuss the characteristics and properties of light and sound.
- PHYI 5 Apply an understanding of magnetism, electric fields, and electricity.
- PHYI 6 Analyze and explain concepts of nuclear physics.

1. **Investigate and apply principles of physical and chemical changes in matter.**
 - a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
 - b. Clarify research questions, and design laboratory investigations. (DOK 3)
 - c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
 - e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
 - f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)

- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Develop an understanding of concepts related to forces and motion.

- a. Use inquiry to investigate and develop an understanding of the kinematics and dynamics of physical bodies. (DOK 3)
 - Vector and scalar quantities
 - Vector problems (solved mathematically and graphically)
 - Vector techniques and free-body diagrams to determine the net force on a body when several forces are acting on it
 - Relations among mass, inertia, and weight
- b. Analyze, describe, and solve problems by creating and utilizing graphs of one-dimensional motion (e.g., position, distance, displacement, time, speed, velocity, acceleration, the special case of freefall). (DOK 2)
- c. Analyze real-world applications to draw conclusions about Newton's three laws of motion. (DOK 2)
- d. Apply the effects of the universal gravitation law to graph and interpret the force between two masses, acceleration due to gravity, and planetary motion. (DOK 2)
 - Situations where g is constant (falling bodies)
 - Concept of centripetal acceleration undergoing uniform circular motion
 - Kepler's third law
 - Oscillatory motion and the mechanics of waves

3. Develop an understanding of concepts related to work and energy.

- a. Explain and apply the conservation of energy and momentum. (DOK 2)
 - Concept of work and applications
 - Concept of kinetic energy, using the elementary work-energy theorem
 - Concept of conservation of energy with simple examples
 - Concepts of energy, work, and power (qualitatively and quantitatively)
 - Principles of impulse in inelastic and elastic collisions
- b. Analyze real-world applications to draw conclusions about mechanical potential energy (the energy of configuration). (DOK 3)
- c. Apply the principles of impulse, and compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions. (DOK 1)
- d. Investigate and summarize the principles of thermodynamics. (DOK 2)
 - How heat energy is transferred from higher temperature to lower temperature until equilibrium is reached
 - Temperature and thermal energy as related to molecular motion and states of matter
 - Problems involving specific heat and heat capacity
 - First and second laws of thermodynamics as related to heat engines, refrigerators, and thermal efficiency
- e. Develop the kinetic theory of ideal gases and explain the concept of Carnot efficiency. (DOK 2)

4. Discuss the characteristics and properties of light and sound.

- a. Describe and model the characteristics and properties of mechanical waves. (DOK 2)
 - Simple harmonic motion
 - Relationships among wave characteristics such as velocity, period, frequency, amplitude, phase, and wavelength
 - Energy of a wave in terms of amplitude and frequency.
 - Standing waves and waves in specific media (e.g., stretched string, water surface, air, etc.)
- b. Differentiate and explain the Doppler effect as it relates to a moving source and to a moving observer. (DOK 1)
- c. Explain the laws of reflection and refraction, and apply Snell's law to describe the relationship between the angles of incidence and refraction. (DOK 2)
- d. Use ray tracing and the thin lens equation to solve real-world problems involving object distance from lenses. (DOK 2)
- e. Investigate and draw conclusions about the characteristics and properties of electromagnetic waves. (DOK 2)

5. Apply an understanding of magnetism, electric fields, and electricity.

- a. Analyze and explain the relationship between electricity and magnetism. (DOK 2)
 - Characteristics of static charge and how a static charge is generated
 - Electric field, electric potential, current, voltage, and resistance as related to Ohm's law
 - Magnetic poles, magnetic flux and field, Ampère's law and Faraday's law
 - Coulomb's law
- b. Use schematic diagrams to analyze the current flow in series and parallel electric circuits, given the component resistances and the imposed electric potential. (DOK 2)
- c. Analyze and explain the relationship between magnetic fields and electrical current by induction, generators, and electric motors. (DOK 2)

6. Analyze and explain concepts of nuclear physics.

- a. Analyze and explain the principles of nuclear physics. (DOK 1)
 - The mass number and atomic number of the nucleus of an isotope of a given chemical element
 - The conservation of mass and the conservation of charge
 - Nuclear decay
- b. Defend the wave-particle duality model of light, using observational evidence. (DOK 3)
 - Quantum energy and emission spectra
 - Photoelectric and Compton effects

Spatial Information Science

- SP 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- SP 2 Develop an understanding of geographic information systems.

- 1. Demonstrate the basic concepts of global positioning systems (GPS). (E)**
 - a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
 - b. Clarify research questions, and design laboratory investigations. (DOK 3)
 - c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, and theory development). (DOK 3)
 - d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences). (DOK 3)
 - e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
 - f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
 - g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)
- 2. Demonstrate the basic concepts of remote sensing. (E, P)**
 - a. Describe the characteristics of the electromagnetic spectrum.
 - b. Using images and graphs, interpret the absorption/reflection spectrum.
 - c. Distinguish between passive vs. active sensor systems.
 - d. Analyze the effects of changes in spatial, temporal, and spectral resolution.
 - e. Analyze the effects on images due to changes in scale.
 - f. Identify the types of sensor platforms.

Zoology

- | | |
|------|--|
| ZO 1 | Apply inquiry-based and problem-solving processes and skills to scientific investigations. |
| ZO 2 | Develop an understanding of levels of organization and animal classification. |
| ZO 3 | Differentiate among animal life cycles, behaviors, adaptations, and relationships. |
| ZO 4 | Demonstrate an understanding of the principles of animal genetic diversity and evolution. |

- 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
 - a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers

- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
- 2. Develop an understanding of levels of organization and animal classification.**
- a. Explain how organisms are classified, and identify characteristics of major groups. (DOK 1)
 - Levels of organization of structures in animals (e.g., cells, tissues, organs, and systems)
 - Characteristics used to classify organisms (e.g., cell structure, biochemistry, anatomy, fossil record, and methods of reproduction)
 - b. Identify and describe characteristics of the major phyla. (DOK 1)
 - Symmetry and body plan
 - Germ layers and embryonic development
 - Organ systems (e.g., digestive, circulatory, excretory, and reproductive)
 - Locomotion and coordination
 - c. Distinguish viruses from bacteria and protists, and give examples. (DOK 1)
 - d. Differentiate among the characteristics of bacteria, archaea, and eucarya. (DOK 1)
 - Phylogenic sequencing of the major phyla
 - Invertebrate characteristics (e.g., habitat, reproduction, body plan, locomotion) of the following phyla: Porifera, Cnidarians, Nematoda, Annelida, Platyhelminthes, Arthropoda, Insecta, Crustacea, Arachnida, Mollusca [Bivalvia and Gastropoda], and Echinodermata)
 - Vertebrate characteristics (e.g., habitat, reproduction, body plan, locomotion) of the following classes: Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, and Mammalia
- 3. Differentiate among animal life cycles, behaviors, adaptations, and relationships.**
- a. Describe life cycles, alternation of generations, and metamorphosis of various animals, and evaluate the advantages and disadvantages of asexual and sexual reproduction. (DOK 1)
 - b. Describe and explain concepts of animal behavior, and differentiate between learned and innate behavior. (DOK 1)
 - Division of labor within a group of animals
 - Communication within animals groups

- Degree of parental care given in animal groups
 - c. Evaluate the unique protective adaptations of animals as they relate to survival. (DOK 2)
 - d. Compare and contrast ecological relationships, and make predictions about the survival of populations under given circumstances. (DOK 3)
 - Terrestrial and aquatic ecosystems
 - Herbivores, carnivores, omnivores, decomposers and other feeding relationships
 - Symbiotic relationships such as mutualism, commensalisms, and parasitism
 - e. Contrast food chains and food webs. (DOK 2)
- 4. Demonstrate an understanding of the principles of animal genetic diversity and evolution.**
- a. Categorize and explain sources of genetic variation on the cellular level (e.g., mutations, crossing over, and nondisjunction) and the population level (e.g., nonrandom mating, migration, etc.). (DOK 2)
 - Relationship between natural selection and evolution
 - Mutations, crossing over, non-disjunction
 - Nonrandom mating, migration, etc.
 - Effects of genetic drift on evolution
 - b. Develop a logical argument defending or refuting issues related to genetic engineering of animals. (DOK 3)

Appendix D: ACT College Readiness Standards

English

E1 Topic Development in Terms of Purpose and Focus

- Identify the basic purpose or role of a specified phrase or sentence.
- Delete a clause or sentence because it is obviously irrelevant to the essay.
- Identify the central idea or main topic of a straightforward piece of writing.
- Determine relevancy when presented with a variety of sentence-level details.
- Identify the focus of a simple essay, applying that knowledge to add a sentence that sharpens that focus or to determine if an essay has met a specified goal.
- Delete material primarily because it disturbs the flow and development of the paragraph.
- Add a sentence to accomplish a fairly straightforward purpose such as illustrating a given statement.
- Apply an awareness of the focus and purpose of a fairly involved essay to determine the rhetorical effect and suitability of an existing phrase or sentence or to determine the need to delete plausible but irrelevant material.
- Add a sentence to accomplish a subtle rhetorical purpose such as to emphasize, to add supporting detail, or to express meaning through connotation.
- Determine whether a complex essay has accomplished a specific purpose.
- Add a phrase or sentence to accomplish a complex purpose, often expressed in terms of the main focus of the essay.

E2 Organization, Unity, and Coherence

- Use conjunctive adverbs or phrases to show time relationship in simple narrative essays (e.g., *then*, *this time*, etc.).
- Select the most logical place to add a sentence in a paragraph.
- Use conjunctive adverbs or phrases to express straightforward logical relationships (e.g., *first*, *afterward*, *in response*).
- Decide the most logical place to add a sentence in an essay.
- Add a sentence that introduces a simple paragraph.
- Determine the need for conjunctive adverbs or phrases to create subtle logical connections between sentences (e.g., *therefore*, *however*, *in addition*).
- Rearrange the sentences in a fairly uncomplicated paragraph for the sake of logic.
- Add a sentence to introduce or conclude the essay or to provide a transition between paragraphs when the essay is fairly straightforward.
- Make sophisticated distinctions concerning the logical use of conjunctive adverbs or phrases, particularly when signaling a shift between paragraphs.
- Rearrange sentences to improve the logic and coherence of a complex paragraph.
- Add a sentence to introduce or conclude a fairly complex paragraph.

- Consider the need for introductory sentences or transitions, basing decisions on a thorough understanding of both the logic and rhetorical effect of the paragraph and essay.

E3 Word Choice in Terms of Style, Tone, Clarity, and Economy

- Revise sentences to correct awkward and confusing arrangements of sentence elements.
- Revise vague nouns and pronouns that create obvious logic problems.
- Delete obviously synonymous and wordy material in a sentence.
- Revise expressions that deviate from the style of an essay.
- Delete redundant material when information is repeated in different parts of speech (e.g., *alarmingly startled*).
- Use the word or phrase most consistent with the style and tone of a fairly straightforward essay.
- Determine the clearest and most logical conjunction to link clauses.
- Revise a phrase that is redundant in terms of the meaning and logic of the entire sentence.
- Identify and correct ambiguous pronoun references.
- Use the word or phrase most appropriate in terms of the content of the sentence and tone of the essay.
- Correct redundant material that involves sophisticated vocabulary and sounds acceptable as conversational English (e.g., *an aesthetic viewpoint* versus *the outlook of an aesthetic viewpoint*).
- Correct vague and wordy or clumsy and confusing writing containing sophisticated language.
- Delete redundant material that involves subtle concepts or that is redundant in terms of the paragraph as a whole.

E4 Sentence Structure and Formation

- Use conjunctions or punctuation to join simple clauses.
- Revise shifts in verb tense between simple clauses in a sentence or between simple adjoining sentences.
- Determine the need for punctuation and conjunctions to avoid awkward sounding sentence fragments and fused sentences.
- Decide the appropriate verb tense and voice by considering the meaning of the entire sentence.
- Recognize and correct marked disturbances of sentence flow and structure (e.g., participial phrase fragments, missing or incorrect relative pronouns, dangling or misplaced modifiers).
- Revise to avoid faulty placement of phrases and faulty coordination and subordination of clauses in sentences with subtle structural problems.
- Maintain consistent verb tense and pronoun person on the basis of the preceding clause or sentence.

- Use sentence-combining techniques, effectively avoiding problematic comma splices, run-on sentences, and sentence fragments, especially in sentences containing compound subjects or verbs.
- Maintain a consistent and logical use of verb tense and pronoun person on the basis of information in the paragraph or essay as a whole.
- Work comfortably with long sentences and complex clausal relationships within sentences, avoiding weak conjunctions between independent clauses and maintaining parallel structure between clauses.

E5 Conventions of Usage

- Solve such basic grammatical problems as how to form the past and past participle of irregular but commonly used verbs and how to form comparative and superlative adjectives.
- Solve such grammatical problems as whether to use an adverb or adjective form, how to ensure straightforward subject–verb and pronoun–antecedent agreement, and which preposition to use in simple contexts.
- Recognize and use the appropriate word in frequently confused pairs such as *there* and *their*, *past* and *passed*, and *led* and *lead*.
- Use idiomatically appropriate prepositions, especially in combination with verbs (e.g., *long for*, *appeal to*).
- Ensure that a verb agrees with its subject when there is some text between the two.
- Ensure that a pronoun agrees with its antecedent when the two occur in separate clauses or sentences.
- Identify the correct past and past participle forms of irregular and infrequently used verbs, and form present–perfect verbs by using *have* rather than *of*.
- Correctly use reflexive pronouns, the possessive pronouns *its* and *your*, and the relative pronouns *who* and *whom*.
- Ensure that a verb agrees with its subject in unusual situations (e.g., when the subject–verb order is inverted or when the subject is an indefinite pronoun).
- Provide idiomatically and contextually appropriate prepositions following verbs in situations involving sophisticated language or ideas.
- Ensure that a verb agrees with its subject when a phrase or clause between the two suggests a different number for the verb.

E6 Conventions of Punctuation

- Delete commas that create basic sense problems (e.g., between verb and direct object).
- Provide appropriate punctuation in straightforward situations (e.g., items in a series).
- Delete commas that disturb the sentence flow (e.g., between modifier and modified element).
- Use commas to set off simple parenthetical phrases.

- Delete unnecessary commas when an incorrect reading of the sentence suggests a pause that should be punctuated (e.g., between verb and direct object clause).
- Use punctuation to set off complex parenthetical phrases.
- Recognize and delete unnecessary commas based on a careful reading of a complicated sentence (e.g., between the elements of a compound subject or compound verb joined by *and*).
- Use apostrophes to indicate simple possessive nouns.
- Recognize inappropriate uses of colons and semicolons.
- Use commas to set off a nonessential/nonrestrictive appositive or clause.
- Deal with multiple punctuation problems (e.g., compound sentences containing unnecessary commas and phrases that may or may not be parenthetical).
- Use an apostrophe to show possession, especially with irregular plural nouns.
- Use a semicolon to indicate a relationship between closely related independent clauses.
- Use a colon to introduce an example or an elaboration.

Math

M1 Basic Operations and Applications

- Perform one-operation computation with whole numbers and decimals.
- Solve problems in one or two steps using whole numbers.
- Perform common conversions (e.g., inches to feet or hours to minutes).
- Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent.
- Solve some routine two-step arithmetic problems.
- Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average.
- Solve multistep arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour).
- Solve word problems containing several rates, proportions, or percentages.
- Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings).

M2 Probability, Statistics, and Data Analysis

- Calculate the average of a list of positive whole numbers.
- Perform a single computation using information from a table or chart.
- Calculate the average of a list of numbers.
- Calculate the average, given the number of data values and the sum of the data values.
- Read tables and graphs.
- Perform computations on data from tables and graphs.

- Use the relationship between the probability of an event and the probability of its complement.
- Calculate the missing data value, given the average and all data values but one.
- Translate from one representation of data to another (e.g., a bar graph to a circle graph).
- Determine the probability of a simple event.
- Exhibit knowledge of simple counting techniques.*
- Calculate the average, given the frequency counts of all the data values.
- Manipulate data from tables and graphs.
- Compute straightforward probabilities for common situations.
- Use Venn diagrams in counting.*
- Calculate or use a weighted average.
- Interpret and use information from figures, tables, and graphs.
- Apply counting techniques.
- Compute a probability when the event and/or sample space is not given or obvious.
- Distinguish between mean, median, and mode for a list of numbers.
- Analyze and draw conclusions based on information from figures, tables, and graphs.
- Exhibit knowledge of conditional and joint probability.

M3 Numbers: Concepts and Properties

- Recognize equivalent fractions and fractions in lowest terms.
- Recognize one-digit factors of a number.
- Identify a digit's place value.
- Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor.
- Find and use the least common multiple.
- Order fractions.
- Work with numerical factors.
- Work with scientific notation.
- Work with squares and square roots of numbers.
- Work problems involving positive integer exponents.*
- Work with cubes and cube roots of numbers.*
- Determine when an expression is undefined.*
- Exhibit some knowledge of the complex numbers.†
- Apply number properties involving prime factorization.
- Apply number properties involving even and odd numbers and factors and multiples.
- Apply number properties involving positive and negative numbers.
- Apply rules of exponents.
- Multiply two complex numbers.†

- Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers.
- Exhibit knowledge of logarithms and geometric sequences.
- Apply properties of complex numbers.

M4 Expressions, Equations, and Inequalities

- Exhibit knowledge of basic expressions (e.g., identify an expression for a total as $b + g$).
- Solve equations in the form $x + a = b$, where a and b are whole numbers or decimals.
- Substitute whole numbers for unknown quantities to evaluate expressions.
- Solve one-step equations having integer or decimal answers.
- Combine like terms (e.g., $2x + 5x$).
- Evaluate algebraic expressions by substituting integers for unknown quantities.
- Add and subtract simple algebraic expressions.
- Solve routine first-degree equations.
- Perform straightforward word-to-symbol translations.
- Multiply two binomials.*
- Solve real-world problems using first-degree equations.
- Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions).
- Identify solutions to simple quadratic equations.
- Add, subtract, and multiply polynomials.*
- Factor simple quadratics (e.g., the difference of squares and perfect square trinomials).*
- Solve first-degree inequalities that do not require reversing the inequality sign.*
- Manipulate expressions and equations.
- Write expressions, equations, and inequalities for common algebra settings.
- Solve linear inequalities that require reversing the inequality sign.
- Solve absolute value equations.
- Solve quadratic equations.
- Find solutions to systems of linear equations.
- Write expressions that require planning and/or manipulating to accurately model a situation.
- Write equations and inequalities that require planning, manipulating, and/or solving.
- Solve simple absolute value inequalities.

M5 Graphical Representations

- Identify the location of a point with a positive coordinate on the number line.
- Locate points on the number line and in the first quadrant.
- Locate points in the coordinate plane.
- Comprehend the concept of length on the number line.*
- Exhibit knowledge of slope.*
- Identify the graph of a linear inequality on the number line.*
- Determine the slope of a line from points or equations.*
- Match linear graphs with their equations.*
- Find the midpoint of a line segment.*
- Interpret and use information from graphs in the coordinate plane.
- Match number line graphs with solution sets of linear inequalities.
- Use the distance formula.
- Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point.
- Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle).†
- Match number line graphs with solution sets of simple quadratic inequalities.
- Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$.
- Solve problems integrating multiple algebraic and/or geometric concepts.
- Analyze and draw conclusions based on information from graphs in the coordinate plane.

M6 Properties of Plane Figures

- Exhibit some knowledge of the angles associated with parallel lines.
- Find the measure of an angle using properties of parallel lines.
- Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90° , 180° , and 360°).
- Use several angle properties to find an unknown angle measure.
- Recognize Pythagorean triples.*
- Use properties of isosceles triangles.*
- Apply properties of 30° - 60° - 90° , 45° - 45° - 90° , similar, and congruent triangles.
- Use the Pythagorean theorem.
- Draw conclusions based on a set of conditions.
- Solve multistep geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas.
- Use relationships among angles, arcs, and distances in a circle.

M7 Measurement

- Estimate or calculate the length of a line segment based on other lengths given on a geometric figure.
- Compute the perimeter of polygons when all side lengths are given.

- Compute the area of rectangles when whole number dimensions are given.
- Compute the area and perimeter of triangles and rectangles in simple problems.
- Use geometric formulas when all necessary information is given.
- Compute the area of triangles and rectangles when one or more additional simple steps are required.
- Compute the area and circumference of circles after identifying necessary information.
- Compute the perimeter of simple composite geometric figures with unknown side lengths.*
- Use relationships involving area, perimeter, and volume of geometric figures to compute another measure.
- Use scale factors to determine the magnitude of a size change.
- Compute the area of composite geometric figures when planning or visualization is required.

M8 Functions

- Evaluate quadratic functions, expressed in function notation, at integer values.
- Evaluate polynomial functions, expressed in function notation, at integer values.†
- Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths.†
- Evaluate composite functions at integer values.†
- Apply basic trigonometric ratios to solve right-triangle problems.†
- Write an expression for the composite of two simple functions.†
- Use trigonometric concepts and basic identities to solve problems.†
- Exhibit knowledge of unit circle trigonometry.†
- Match graphs of basic trigonometric functions with their equations.

Notes

- Students who score in the 1–12 range are most likely beginning to develop the knowledge and skills assessed in the other ranges.
- Standards followed by an asterisk (*) apply to the PLAN and ACT Mathematics tests only.
- Standards followed by a dagger (†) apply to the ACT Mathematics test only.

Reading

R1 Main Ideas and Author's Approach

- Recognize a clear intent of an author or narrator in uncomplicated literary narratives.
- Identify a clear main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Infer the main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.

- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in uncomplicated passages.
- Identify a clear main idea or purpose of any paragraph or paragraphs in uncomplicated passages.
- Infer the main idea or purpose of straightforward paragraphs in more challenging passages.
- Summarize basic events and ideas in more challenging passages.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in more challenging passages.
- Infer the main idea or purpose of more challenging passages or their paragraphs.
- Summarize events and ideas in virtually any passage.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in virtually any passage.
- Identify clear main ideas or purposes of complex passages or their paragraphs.

R2 Supporting Details

- Locate basic facts (e.g., names, dates, events) clearly stated in a passage.
- Locate simple details at the sentence and paragraph level in uncomplicated passages.
- Recognize a clear function of a part of an uncomplicated passage.
- Locate important details in uncomplicated passages.
- Make simple inferences about how details are used in passages.
- Locate important details in more challenging passages.
- Locate and interpret minor or subtly stated details in uncomplicated passages.
- Discern which details, though they may appear in different sections throughout a passage, support important points in more challenging passages.
- Locate and interpret minor or subtly stated details in more challenging passages.
- Use details from different sections of some complex informational passages to support a specific point or argument.
- Locate and interpret details in complex passages.
- Understand the function of a part of a passage when the function is subtle or complex.

R3 Sequential, Comparative, and Cause–Effect Relationships

- Determine when (e.g., first, last, before, after) or if an event occurred in uncomplicated passages.
- Recognize clear cause–effect relationships described within a single sentence in a passage.
- Identify relationships between main characters in uncomplicated literary narratives.
- Recognize clear cause–effect relationships within a single paragraph in uncomplicated literary narratives.
- Order simple sequences of events in uncomplicated literary narratives.

- Identify clear relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear cause–effect relationships in uncomplicated passages.
- Order sequences of events in uncomplicated passages.
- Understand relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear relationships between characters, ideas, and so forth in more challenging literary narratives.
- Understand implied or subtly stated cause–effect relationships in uncomplicated passages.
- Identify clear cause–effect relationships in more challenging passages.
- Order sequences of events in more challenging passages.
- Understand the dynamics between people, ideas, and so forth in more challenging passages.
- Understand implied or subtly stated cause–effect relationships in more challenging passages.
- Order sequences of events in complex passages.
- Understand the subtleties in relationships between people, ideas, and so forth in virtually any passage.
- Understand implied, subtle, or complex cause–effect relationships in virtually any passage.

R4 Meaning of Words

- Understand the implication of a familiar word or phrase and of simple descriptive language.
- Use context to understand basic figurative language.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in uncomplicated passages.
- Use context to determine the appropriate meaning of virtually any word, phrase, or statement in uncomplicated passages.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in more challenging passages.
- Determine the appropriate meaning of words, phrases, or statements from figurative or somewhat technical contexts.
- Determine, even when the language is richly figurative and the vocabulary is difficult, the appropriate meaning of context-dependent words, phrases, or statements in virtually any passage.

R5 Generalizations and Conclusions

- Draw simple generalizations and conclusions about the main characters in uncomplicated literary narratives.
- Draw simple generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.

- Draw generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw simple generalizations and conclusions using details that support the main points of more challenging passages.
- Draw subtle generalizations and conclusions about characters, ideas, and so forth in uncomplicated literary narratives.
- Draw generalizations and conclusions about people, ideas, and so forth in more challenging passages.
- Use information from one or more sections of a more challenging passage to draw generalizations and conclusions about people, ideas, and so forth.
- Draw complex or subtle generalizations and conclusions about people, ideas, and so forth, often by synthesizing information from different portions of the passage.
- Understand and generalize about portions of a complex literary narrative.

Science

S1 Interpretation of Data

- Select a single piece of data (numerical or non-numerical) from a simple data presentation (e.g., a table or graph with two or three variables, a food web diagram).
- Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, axis labels).
- Select two or more pieces of data from a simple data presentation.
- Understand basic scientific terminology.
- Find basic information in a brief body of text.
- Determine how the value of one variable changes as the value of another variable changes in a simple data presentation.
- Select data from a complex data presentation (e.g., a table or graph with more than three variables, a phase diagram).
- Compare or combine data from a simple data presentation (e.g., order or sum data from a table).
- Translate information into a table, graph, or diagram.
- Compare or combine data from two or more simple data presentations (e.g., categorize data from a table using a scale from another table).
- Compare or combine data from a complex data presentation.
- Interpolate between data points in a table or graph.
- Determine how the value of one variable changes as the value of another variable changes in a complex data presentation.
- Identify and/or use a simple (e.g., linear) mathematical relationship between data.
- Analyze given information when presented with new, simple information.
- Compare or combine data from a simple data presentation with data from a complex data presentation.

- Identify and/or use a complex (e.g., nonlinear) mathematical relationship between data.
- Extrapolate from data points in a table or graph.
- Compare or combine data from two or more complex data presentations.
- Analyze given information when presented with new, complex information.

S2 Scientific Investigation

- Understand the methods and tools used in a simple experiment.
- Understand the methods and tools used in a moderately complex experiment.
- Understand a simple experimental design.
- Identify a control in an experiment.
- Identify similarities and differences between experiments.
- Understand the methods and tools used in a complex experiment.
- Understand a complex experimental design.
- Predict the results of an additional trial or measurement in an experiment.
- Determine the experimental conditions that would produce specified results.
- Determine the hypothesis for an experiment.
- Identify an alternate method for testing a hypothesis.
- Understand precision and accuracy issues.
- Predict how modifying the design or methods of an experiment will affect results.
- Identify an additional trial or experiment that could be performed to enhance or evaluate experimental results.

S3 Evaluation of Models, Inferences, and Experimental Results

- Select a simple hypothesis, prediction, or conclusion that is supported by a data presentation or a model.
- Identify key issues or assumptions in a model.
- Select a simple hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a simple hypothesis or conclusion and why.
- Identify strengths and weaknesses in one or more models.
- Identify similarities and differences between models.
- Determine which model(s) is/are supported or weakened by new information.
- Select a data presentation or a model that supports or contradicts a hypothesis, prediction, or conclusion.
- Select a complex hypothesis, prediction, or conclusion that is supported by a data presentation or model.
- Determine whether new information supports or weakens a model and why.
- Use new information to make a prediction based on a model.
- Select a complex hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.

- Determine whether given information supports or contradicts a complex hypothesis or conclusion and why.

Writing

W1 Expressing Judgments

- Show a little understanding of the persuasive purpose of the task, but neglect to take or to maintain a position on the issue in the prompt.
- Show limited recognition of the complexity of the issue in the prompt.
- Show a basic understanding of the persuasive purpose of the task by taking a position on the issue in the prompt but may not maintain that position.
- Show a little recognition of the complexity of the issue in the prompt by acknowledging, but only briefly describing, a counterargument to the writer's position.
- Show understanding of the persuasive purpose of the task by taking a position on the issue in the prompt.
- Show some recognition of the complexity of the issue in the prompt by doing the following:
 - Acknowledging counterarguments to the writer's position
 - Providing some response to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a broad context for discussion.
- Show recognition of the complexity of the issue in the prompt by doing the following:
 - Partially evaluating implications and/or complications of the issue
 - Posing and partially responding to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a critical context for discussion.
- Show understanding of the complexity of the issue in the prompt by doing the following:
 - Examining different perspectives
 - Evaluating implications or complications of the issue
 - Posing and fully discussing counterarguments to the writer's position

W2 Focusing on the Topic

- Maintain a focus on the general topic in the prompt through most of the essay.
- Maintain a focus on the general topic in the prompt throughout the essay.
- Maintain a focus on the general topic in the prompt throughout the essay, and attempt a focus on the specific issue in the prompt.
- Present a thesis that establishes focus on the topic.
- Maintain a focus on discussion of the specific topic and issue in the prompt throughout the essay.

- Present a thesis that establishes a focus on the writer's position on the issue.
- Maintain a clear focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a critical thesis that clearly establishes the focus on the writer's position on the issue.

W3 Developing a Position

- Offer a little development, with one or two ideas; if examples are given, they are general and may not be clearly relevant; resort often to merely repeating ideas.
- Show little or no movement between general and specific ideas and examples.
- Offer limited development of ideas using a few general examples; resort sometimes to merely repeating ideas.
- Show little movement between general and specific ideas and examples.
- Develop ideas by using some specific reasons, details, and examples.
- Show some movement between general and specific ideas and examples.
- Develop most ideas fully, using some specific and relevant reasons, details, and examples.
- Show clear movement between general and specific ideas and examples.
- Develop several ideas fully, using specific and relevant reasons, details, and examples.
- Show effective movement between general and specific ideas and examples.

W4 Organizing Ideas

- Provide a discernible organization with some logical grouping of ideas in parts of the essay.
- Use a few simple and obvious transitions.
- Present a discernible, though minimally developed, introduction and conclusion.
- Provide a simple organization with logical grouping of ideas in parts of the essay.
- Use some simple and obvious transitional words, though they may at times be inappropriate or misleading.
- Present a discernible, though underdeveloped, introduction and conclusion.
- Provide an adequate but simple organization with logical grouping of ideas in parts of the essay but with little evidence of logical progression of ideas.
- Use some simple and obvious, but appropriate, transitional words and phrases.
- Present a discernible introduction and conclusion with a little development.
- Provide unity and coherence throughout the essay, sometimes with a logical progression of ideas.
- Use relevant, though at times simple and obvious, transitional words and phrases to convey logical relationships between ideas.
- Present a somewhat developed introduction and conclusion.
- Provide unity and coherence throughout the essay, often with a logical progression of ideas.

- Use relevant transitional words, phrases, and sentences to convey logical relationships between ideas.
- Present a well-developed introduction and conclusion.

W5 Using Language

- Show limited control of language by doing the following:
 - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes significantly impede understanding
 - Using simple vocabulary
 - Using simple sentence structure
 - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes impede understanding
 - Using simple but appropriate vocabulary
 - Using a little sentence variety, though most sentences are simple in structure
 - Correctly employing many of the conventions of standard English grammar, usage, and mechanics but with some distracting errors that may occasionally impede understanding
 - Using appropriate vocabulary
 - Using some varied kinds of sentence structures to vary pace
 - Correctly employing most conventions of standard English grammar, usage, and mechanics with a few distracting errors but none that impede understanding
 - Using some precise and varied vocabulary
 - Using several kinds of sentence structures to vary pace and to support meaning
 - Correctly employing most conventions of standard English grammar, usage, and mechanics with just a few, if any, errors
 - Using precise and varied vocabulary
 - Using a variety of kinds of sentence structures to vary pace and to support meaning