Information and Communication Technologies

Sector Description

Information and Communication Technologies (ICT) have expanded the need for employees who can understand, manage, and support all rapidly emerging, evolving, and converging computer, software, networking, telecommunications, Internet, programming, and information systems. Essential skills for careers in the ICT sector include understanding systems that support the management and flow of data, the ability to work well and communicate clearly with people, and the ability to manage projects efficiently. The ICT sector meets national criteria for high demand, high wages, and high skills and provides students with excellent opportunities for interesting work and good pay. More than 70 percent of jobs in this sector will require a bachelor's degree or higher by 2018.

Information and Communication Technologies
Knowledge and Performance Anchor Standards

1.0 Academics
Analyze and apply appropriate academic standards required for successful industry sector pathway completion leading to postsecondary education and employment. Refer to the Information and Communication Technologies academic alignment matrix for identification of standards.

2.0 Communications
Acquire and accurately use Information and Communication Technologies sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats.
(Direct alignment with LS 9-10, 11-12.6)

2.1   Recognize the elements of communication using a sender–receiver model.
2.2   Identify barriers to accurate and appropriate communication.
2.3   Interpret verbal and nonverbal communications and respond appropriately.
2.4   Demonstrate elements of written and electronic communication such as accurate spelling, grammar, and format.
2.5   Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
2.6   Advocate and practice safe, legal, and responsible use of digital media information and communications technologies.
2.7   Use technical writing and communication skills to work effectively with diverse groups of people.
2.8   Understand the principles of a customer-oriented service approach to users.

3.0 Career Planning and Management
Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.
(Direct alignment with SLS 11-12.2)

3.1   Identify personal interests, aptitudes, information, and skills necessary for informed career decision making.
3.2   Evaluate personal character traits such as trust, respect, and responsibility and understand the impact they can have on career success.
3.3   Explore how information and communication technologies are used in career planning and decision making.
3.4   Research the scope of career opportunities available and the requirements for education, training, certification, and licensure.
3.5   Integrate changing employment trends, societal needs, and economic conditions into career planning.
3.6   Recognize the role and function of professional organizations, industry associations, and organized labor in a productive society.

3.7   Recognize the importance of small business in the California and global economies.

3.8   Understand how digital media are used by potential employers and postsecondary agencies to evaluate candidates.

3.9   Develop a career plan that reflects career interests, pathways, and postsecondary options.

4.0 Technology

Use existing and emerging technology, to investigate, research, and produce products and services, including new information, as required in the Information and Communication Technologies sector workplace environment.
(Direct alignment with WS 11-12.6)

4.1   Use electronic reference materials to gather information and produce products and services.

4.2   Employ technology based communications responsibly and effectively to explore complex systems and issues.

4.3   Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources.

4.4   Discern the quality and value of information collected using digital technologies, and recognize bias and intent of the associated sources.

4.5   Research past, present, and projected technological advances as they impact a particular pathway.

4.6   Assess the value of various information and communication technologies to interact with constituent populations as part of a search of the current literature or in relation to the information task.

5.0 Problem Solving and Critical Thinking

Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the Information and Communication Technologies sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques. (Direct alignment with WS 11-12.7)

5.1   Identify and ask significant questions that clarify various points of view to solve problems.

5.2   Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate.

5.3   Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment.

5.4   Interpret information and draw conclusions, based on the best analysis, to make informed decisions.

5.5   Use a logical and structured approach to isolate and identify the source of problems and to resolve problems.

5.6   Know the available resources for identifying and resolving problems.

5.7   Work out problems iteratively and recursively.

5.8   Create and use algorithms and solve problems.

5.9   Deconstruct large problems into components to solve.
5.10   Use multiple layers of abstraction.
5.11   Understand the concept of base systems, including binary and hexadecimal.
5.12   Apply the concepts of Boolean logic to decision making and searching.

6.0 Health and Safety

Demonstrate health and safety procedures, regulations, and personal health practices and determine the meaning of symbols, key terms, and domain-specific words and phrases as related to the Information and Communication Technologies sector workplace environment. (Direct alignment with RSTS 9-10, 11-12.4)

6.1   Locate, and adhere to, Material Safety Data Sheet (MSDS) instructions.
6.2   Interpret policies, procedures, and regulations for the workplace environment, including employer and employee responsibilities.
6.3   Use health and safety practices for storing, cleaning, and maintaining tools, equipment, and supplies.
6.4   Practice personal safety when lifting, bending, or moving equipment and supplies.
6.5   Demonstrate how to prevent and respond to work-related accidents or injuries; this includes demonstrating an understanding of ergonomics.
6.6   Maintain a safe and healthful working environment.
6.7   Be informed of laws/acts pertaining to the Occupational Safety and Health Administration (OSHA).
6.8   Maintain a safe and healthful working environment.
6.9   Dispose of e-waste properly, understanding the health, environmental, and legal risks of improper disposal.
6.10   Act conscientiously regarding the use of natural resources (e.g., paper, ink, etc.)
6.11   Conserve energy while computing (e.g., turn off equipment at night, power-saving settings, etc.)

7.0 Responsibility and Flexibility

Initiate, and participate in, a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the Information and Communication Technologies sector workplace environment and community settings. (Direct alignment with SLS 9-10, 11-12.1)

7.1   Recognize how financial management impacts the economy, workforce, and community.
7.2   Explain the importance of accountability and responsibility in fulfilling personal, community, and workplace roles.
7.3   Understand the need to adapt to changing and varied roles and responsibilities.
7.4   Practice time management and efficiency to fulfill responsibilities.
7.5   Apply high-quality techniques to product or presentation design and development.
7.6   Demonstrate knowledge and practice of responsible financial management.

7.7 Demonstrate the qualities and behaviors that constitute a positive and professional work demeanor, including appropriate attire for the profession.

7.8 Explore issues of global significance and document the impact on the Information and Communication Technologies sector.

8.0 Ethics and Legal Responsibilities

Practice professional, ethical, and legal behavior, responding thoughtfully to diverse perspectives and resolving contradictions when possible, consistent with applicable laws, regulations, and organizational norms. (Direct alignment with SLS 11-12.1d)

8.1 Access, analyze, and implement quality assurance standards of practice.

8.2 Identify local, district, state, and federal regulatory agencies, entities, laws, and regulations related to the Information and Communication Technologies industry sector.

8.3 Demonstrate ethical and legal practices consistent with Information and Communication Technologies sector workplace standards.

8.4 Explain the importance of personal integrity, confidentiality, and ethical behavior in the workplace.

8.5 Analyze organizational culture and practices within the workplace environment.

8.6 Adhere to copyright and intellectual property laws and regulations, and use and appropriately cite proprietary information.

8.7 Conform to rules and regulations regarding sharing of confidential information, as determined by Information and Communication Technologies sector laws and practices.

8.8 Identify legal and ethical issues that have proliferated with increased technology adoption, including hacking, scamming, and breach of privacy.

9.0 Leadership and Teamwork

Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision making, benefits of workforce diversity, and conflict resolution such as those practiced in the Future Business Leaders of America and SkillsUSA career technical student organization. (Direct alignment with SLS 11-12.1b)

9.1 Define leadership and identify the responsibilities, competencies, and behaviors of successful leaders.

9.2 Identify the characteristics of successful teams, including leadership, cooperation, collaboration, and effective decision-making skills as applied in groups, teams, and career technical student organization activities.

9.3 Understand the characteristics and benefits of teamwork, leadership, and citizenship in the school, community, and workplace setting.

9.4 Explain how professional associations and organizations and associated leadership development and competitive career development activities enhance academic preparation, promote career choices, and contribute to employment opportunities.

9.5   Understand that the modern world is an international community and requires an expanded global view.
9.6   Respect individual and cultural differences and recognize the importance of diversity in the workplace.
9.7   Participate in interactive teamwork to solve real Information and Communication Technologies sector issues and problems.

10.0 Technical Knowledge and Skills

Apply essential technical knowledge and skills common to all pathways in the Information and Communication Technologies sector, following procedures when carrying out experiments or performing technical tasks. (Direct alignment with WS 11-12.6)

10.1   Interpret and explain terminology and practices specific to the Information and Communication Technologies sector.
10.2   Comply with the rules, regulations, and expectations of all aspects of the Information and Communication Technologies sector.
10.3   Construct projects and products specific to the Information and Communication Technologies sector requirements and expectations.
10.4   Collaborate with industry experts for specific technical knowledge and skills.
10.5   Understand the major software and hardware components of a computer and a network and how they relate to each other.
10.6   Understand data sizes of various types of information (text, pictures, sound, video, etc.) and data capacity of various forms of media.
10.7   Understand the SI (metric) prefixes commonly used in computing including, at least, kilo, mega, giga, and tera.
10.8   Understand security concepts including authorization, rights, and encryption.
10.9   Use common industry-standard software and their applications including word processing, spreadsheets, databases, and multimedia software.
10.10   Manage files in a hierarchical system.
10.11   Know multiple ways in which to transfer information and resources (e.g., text, data, sound, video, still images) between software programs and systems.
10.12   Know appropriate search procedures for different types of information, sources, and queries.
10.13   Evaluate the accuracy, relevance, and comprehensiveness of retrieved information.
10.14   Analyze the effectiveness of online information resources to support collaborative tasks, research, publications, communications, and increased productivity.

11.0 Demonstration and Application

Demonstrate and apply the knowledge and skills contained in the Information and Communication Technologies anchor standards, pathway standards, and performance indicators in classroom, laboratory, and workplace settings, and through career technical student organizations such as Future Business Leaders of America and SkillsUSA.

11.1 Utilize work-based/workplace learning experiences to demonstrate and expand upon knowledge and skills gained during classroom instruction and laboratory practices specific to the Information and Communication Technologies sector program of study.

11.2 Demonstrate proficiency in a career technical pathway that leads to certification, licensure, and/or continued learning at the postsecondary level.

11.3 Demonstrate entrepreneurship skills and knowledge of self-employment options and innovative ventures.

11.4 Employ entrepreneurial practices and behaviors appropriate to Information and Communication Technologies sector opportunities.

11.5 Create a portfolio, or similar collection of work, that offers evidence through assessment and evaluation of skills and knowledge competency as contained in the anchor standards, pathway standards, and performance indicators.

Information and Communication Technologies
Pathway Standards

A. Information Support and Services Pathway

Students in the Information Support and Services pathway prepare for careers that involve the implementation of computer services and software, support of multimedia products and services, provision of technical assistance, creation of technical documentation, and the administration and management of information and communication systems. Mastery of information and communication technologies is the foundation for all successful business organizations today. Persons with expertise in information and communication technologies support and services are in high demand for a variety of positions in business and industry.

Sample occupations associated with this pathway:
♦ Computer and Information Systems Manager
♦ Computer User Support Specialist
♦ Database Administrator
♦ Document Management Specialist
♦ Business Intelligence Analyst

A1.0 Describe the role of information and communication technologies in organizations.
    A1.1 Describe how technology is integrated into business processes.
    A1.2 Identify common organizational, technical, and financial risks associated with the implementation and use of information and communication systems.
    A1.3 Model business processes using tools such as organization charts, flowcharts, and timelines.
    A1.4 Analyze and design business processes in a cycle of continual improvement.

A2.0 Acquire, install, and implement software and systems.
    A2.1 Identify and list the criteria and processes for evaluating the functions of information systems.
    A2.2 Investigate, evaluate, select, and use major types of software, services, and vendors.
    A2.3 Install software and setup hardware.
    A2.4 Define and use appropriate naming conventions and file management strategies.

A3.0 Access and transmit information in a networked environment.
- A3.1 Identify and apply multiple ways to transfer information and resources (e.g., text, data, audio, video, still images) between software programs and systems.
- A3.2 Validate and cite Internet resources.
- A3.3 Recognize where processes are running in a networked environment (e.g., client access, remote access).
- A3.4 Identify and describe the layered nature of computing and networking such as the Open Systems Interconnect (OSI) model.
- A3.5 Use multiple online search techniques and resources to acquire information.
- A3.6 Describe and contrast the differences between various Internet protocols: hypertext transfer protocol (http), hypertext transfer protocol secure (https), file transfer protocol (ftp), simple mail transfer protocol (smtp).

A4.0 Administer and maintain software and systems.
- A4.1 Use different systems and associated utilities to perform such functions as file management, backup and recovery, and execution of programs.
- A4.2 Use a command line interface.
- A4.3 Automate common tasks using macros or scripting.
- A4.4 Evaluate the systems-development life cycle and develop appropriate plans to maintain a given system after assessing its impact on resources and total cost of ownership (TCO).

A5.0 Identify requirements for maintaining secure network systems.
- A5.1 Follow laws, regulatory guidelines, policies, and procedures to ensure the security and integrity of information systems.
- A5.2 Identify potential attack vectors and security threats.
- A5.3 Take preventative measures to reduce security risks (e.g., strong passwords, avoid social engineering ploys, limit account permissions).
- A5.4 Use security software and hardware to protect systems from attack and alert of potential threats, anti-malware software, and firewalls.

A6.0 Diagnose and solve software, hardware, networking, and security problems.
- A6.1 Use available resources to identify and resolve problems using knowledge bases, forums, and manuals.
- A6.2 Use a logical and structured approach to isolate and identify the source of problems and to resolve problems.
- A6.3 Use specific problem solving strategies appropriate to troubleshooting, eliminating possibilities, or guess and check.
- A6.4 Evaluate support needs for different data and systems configurations.

A6.5   Evaluate solution methods recognizing the trade-offs of troubleshooting vs. reloading, reimaging, or restoring to factory defaults using a sandbox environment.

A6.6   Distinguish types of symptoms and which component's issue could exhibit those symptoms: the user, hardware, network, or software.

A6.7   Diagram the underlying processes of a system that are likely involved in a problem.

A7.0   Support and train users on various software, hardware, and network systems.

A7.1   Recognize the scope of duties ICT support staff have and tiered levels of support.

A7.2   Describe and apply the principles of a customer-oriented service approach to supporting users.

A7.3   Use technical writing and communication skills to work effectively with diverse groups of people, including users with less technical abilities.

A7.4   Document technical support provided such as using a ticketing system.

A7.5   Train users to assist them in being self-supporting: formal classes, one-on-one interactions, and process and how-to guides.

A8.0   Manage and implement information, technology, and communication projects.

A8.1   Develop the purpose and scope of a project.

A8.2   Acquire, use, and manage necessary internal and external resources when supporting various organizational systems.

A8.3   Use various tools to manage projects involving the development of information and communication systems.

A8.4   Analyze business problems by using functional and cost-benefit perspectives.

A8.5   Design, develop, implement, and monitor a project by creating and integrating technologies.

A8.6   Use a systematic method of continual improvement; plan, do, check, act (PDCA), total quality (TQ), or Six Sigma.

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B. Networking Pathway

Students in the Networking pathway prepare for careers that involve network analysis, planning, and implementation, including the design, installation, maintenance, and management of network systems. The successful establishment, maintenance, and securing of information and communication technologies infrastructure is critical to the success of every twenty-first century organization. Employment continues to grow for persons with expertise in networking.

Sample occupations associated with this pathway:
- Computer Security Specialist
- Network Technician
- Network Engineer
- Network Administrator
- Telecommunication Specialist

B1.0   Identify and describe the principles of networking and the technologies, models, and protocols used in a network.

    B1.1   Define the terminology used in the design, assembly, configuration, and implementation of networks.

    B1.2   List the fundamental elements of the major networking models established by the industry standards of recognized organizations: the Open System Interconnect (OSI) or transmission-control/Internet protocol (TCP/IP) models.

    B1.3   Identify and explain how data, voice, and video/communications are carried through the most common network media.

    B1.4   List the characteristics, advantages, and disadvantages of the various networking presentation functions, data formatting, data encryption, and data compression.

    B1.5   Explain the characteristics of networking hardware and applications and the methods to deploy them.

    B1.6   Design and document data/communication systems networks.

B2.0   Identify, describe, and implement network media and physical topologies.

    B2.1   Use appropriate wiring and wireless standards and plan, install, and maintain media (copper, fiber, and wireless) for a variety of network systems.

    B2.2   Demonstrate standard procedures and practices for safely using tools and working safely around the electrical environment in various networking systems.

B2.3 Test and maintain wired and wireless network communications components and systems.

B3.0 Install, configure, and differentiate between common network devices.
B3.1 Identify and describe the functions of various network devices, including network connectivity hardware.
B3.2 Describe the differences between various network environments: peer-to-peer, client-server, thin client, virtualized, internetworks, intranets, and extranets.
B3.3 Distinguish between the topologies and protocols of local area networks and those of wide area networks.
B3.4 Confirm operating parameters, apply test procedures, make necessary adjustments, and assemble the components of a network system or subsystem.
B3.5 Configure the major addressing and routing protocols used in networking.
B3.6 Implement a functional wired and wireless network, including the installation and configuration of components, software, and plug-ins.
B3.7 Evaluate, select, and deploy a variety of network architectures, information and communication technologies, and protocols.

B4.0 Demonstrate proper network administration and management skills.
B4.1 Identify and use network tools to troubleshoot and verify network availability and performance.
B4.2 Identify common customer policies and procedures, including those for management of incidents.
B4.3 Identify the implications of major protocols and international standards and their impact on network management.
B4.4 Apply appropriate technologies to improve network performance for data, voice, and video transmission.
B4.5 Apply the proper security patches, updates, and procedures necessary to maintain and support a network.
B4.6 Use common help-desk tools and resources, such as incident tracking, knowledge database, and staffing to administer and manage a network.
B4.7 Apply known effective methods of disseminating information and instruction to users.
B4.8 Use project management skills and tools for managing and maintaining various types of networks.
B4.9 Analyze network system interdependencies and constraints.

B5.0 Demonstrate how to communicate and interpret information clearly in industry-standard visual and written formats.
B5.1 Classify and use various electronic components, symbols, abbreviations, and media common to network topology diagrams.
B5.2 Interpret, organize, and communicate complex network diagrams by using information collected from detailed drawings.

B6.0 Use and assess network communication applications and infrastructure.
B6.1 Identify and document the appropriate uses of networking services, products, and applications.
B6.2 Evaluate the features of communications software products in terms of their appropriateness to organizational tasks.
B6.3 Configure compatible systems across various platforms and types of media.

B7.0 Analyze a customer's organizational needs and requirements to identify networking needs.
B7.1 Describe the effective management of human, financial, and communications resources from the standpoints of the user and the provider.
B7.2 Diagram physical and logical layouts of networks that support information and communication technologies.
B7.3 Evaluate emerging products, services, and business models in relation to the creation, setup, and management of networks that support information and communication technologies.
B7.4 Evaluate, create, and process voice, video, and data transmissions.

B8.0 Identify security threats to a network and describe general methods to mitigate those threats.
B8.1 Identify and define command network security threats: hackers, crackers, viruses, worms, and Trojan horses.
B8.2 Describe the importance of classifying appropriate monitoring devices and procedures for quick identification and prevention of security violations.
B8.3 List the policies and procedures for routine administration, such as user agreement, incident reporting, and recovery for users.
B8.4 Identify common potential risks and entrance points, including internal and external risks, and the tools used to neutralize them: firewalls; monitoring; and antivirus, spyware, and spam protection.
B8.5 Identify and apply common techniques for disaster prevention and recovery.

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C. Software and Systems Development Pathway
Students in the Software and Systems Development pathway prepare for careers related to computer science that involve the design, development, implementation, maintenance, and management of systems that rely on software programs to satisfy the operational needs of modern business organizations. Persons with expertise in systems development and programming are critical to support operations like electronic commerce, medical records management, retail sales and inventory management, digital entertainment, and use of energy.

Sample occupations associated with this pathway:
♦ Computer Programmer
♦ Software Developer/Applications
♦ Information Security Analyst
♦ Web Developer
♦ E-Business/E-Commerce Specialist

C1.0 Identify and apply the systems development process.
    C1.1 Identify the phases of the systems development life cycle, including analysis, design, programming, testing, implementation, maintenance, and improvement.
    C1.2 Identify and describe models of systems development, systems development life cycle (SDLC), and agile computing.
    C1.3 Identify and describe how specifications and requirements are developed for new and existing software applications.
    C1.4 Work as a member of, and within the scope and boundaries of, a development project team.
    C1.5 Track development project milestones using the concept of versions.
    C1.6 Diagram processes using flowcharts and the Unified Modeling Language.

C2.0 Define and analyze systems and software requirements.
    C2.1 Describe the major purposes and benefits of development, including automation, improving productivity, modeling and analysis, and entertainment.
    C2.2 Recognize and prevent unintended consequences of development work: programming errors, security issues, health and environmental risks, and privacy concerns.
    C2.3 Develop strategies that target the specific needs and desires of the customer.
    C2.4 Analyze customers' needs for development.

C2.5 Determine and document the requirements and alternative solutions to fulfill the customers' needs.

C3.0 Create effective interfaces between humans and technology.
C3.1 Describe and apply the basic process of input, processing, and output.
C3.2 Design effective and intuitive interfaces using knowledge of cognitive, physical, and social interactions.
C3.3 Support methods of accessibility for all potential users, including users with disabilities and non-English speaking users.

C4.0 Develop software using programming languages.
C4.1 Identify and describe the abstraction level of programming languages from low-level, hardware-based languages to high-level, interpreted, Web-based languages.
C4.2 Describe the interaction and integration of programming languages and protocols such as how client-side programming can work with server-side programming to use a query language to access a database.
C4.3 Identify and use different authoring tools and integrated development environments (IDEs).
C4.4 Identify and apply data types and encoding.
C4.5 Demonstrate awareness of various programming paradigms, including procedural, object oriented, event-driven, and multithreaded programing.
C4.6 Use proper programming language syntax.
C4.7 Use various data structures, arrays, objects, files, and databases.
C4.8 Use object oriented programming concepts, properties, methods, and inheritance.
C4.9 Create programs using control structures, procedures, functions, parameters, variables, error recovery, and recursion.
C4.10 Create and know the comparative advantages of various queue, sorting, and searching algorithms.
C4.11 Document development work for various audiences, such as comments for other programmers, and manuals for users.

C5.0 Test, debug, and improve software development work.
C5.1 Identify the characteristics of reliable, effective, and efficient products.
C5.2 Describe the ways in which specification changes and technological advances can require the modification of programs.
C5.3 Use strategies to optimize code for improved performance.
C5.4 Test software and projects.
C5.5 Evaluate results against initial requirements.
C5.6 Debug software as part of the quality assurance process.

C6.0 Integrate a variety of media into development projects.
  C6.1 Identify the basic design elements necessary to produce effective print, video, audio, and interactive media.
  C6.2 Describe the various encoding methods of media and trade-offs: vector graphics vs. bitmaps, and bit depth.
  C6.3 Use media design and editing software: keyframe animation, drawing software, image editors, and three-dimensional design.
  C6.4 Develop a presentation or other multimedia project: video, game, or interactive Web sites, from storyboard to production.
  C6.5 Analyze the use of media to determine the appropriate file format and level of compression.
  C6.6 Integrate media into a full project using appropriate tools.
  C6.7 Create and/or capture professional-quality media, images, documents, audio, and video clips.

C7.0 Develop Web and online projects.
  C7.1 Identify the hardware (server) and software required for Web hosting and other services.
  C7.2 Describe the full process of online content delivery, registering domain names, setting up hosting, and setting up e-mail addresses.
  C7.3 Attract Web-site visitors through search engine optimization using various strategies like keywords and meta-tags.
  C7.4 Enable e-commerce capabilities to sell products, create a shopping cart, and handle credit card transactions.
  C7.5 Create an online project, Web-based business, and e-portfolio.
  C7.6 Optimize fast delivery and retrieval of online content such as Web pages.

C8.0 Develop databases.
  C8.1 Describe the critical function of databases in modern organizations.
  C8.2 Identify and use the basic structures of databases, fields, records, tables, and views.
  C8.3 Identify and explain the types of relationships between tables (one-to-one, one-to-many, many-to-many) and use methods to establish these relationships, including primary keys, foreign keys, and indexes.
  C8.4 Use data modeling techniques to create databases based upon business needs.
  C8.5 Use queries to extract and manipulate data (select queries, action queries).
  C8.6 Develop databases that are properly normalized using appropriate schemas.

C8.7 Export and import data to and from other applications and a database recognizing the limitations and challenges inherent in the process.

C8.8 Analyze and display data to assist with decision making using methods like cross tabulations, graphs, and charts.

C9.0 Develop software for a variety of devices, including robotics.

C9.1 Demonstrate awareness of the applications of device development work, including personalized computing, robotics, and smart appliances.

C9.2 Install equipment, assemble hardware, and perform tests using appropriate tools and technology.

C9.3 Use hardware to gain input, process information, and take action.

C9.4 Apply the concepts of embedded programming, including digital logic, machine-level representation of data, and memory-system organization.

C9.5 Program a micro-controller for a device or robot.

C10.0 Develop intelligent computing.

C10.1 Describe models of intelligent behavior and what distinguishes humans from machines.

C10.2 Describe the major areas of intelligent computing, including perception, proximity, processing, and control.

C10.3 Know artificial intelligence methods such as neural networks, Bayesian inferences, fuzzy logic, and finite state machines.

C10.4 Implement artificial intelligent behavior through various methods: mathematical modeling, reinforcement learning, and probabilistic analysis.

**Information and Communication Technologies
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D. Games and Simulation Pathway

Students in the Game and Simulation pathway learn relevant technical knowledge and skills to prepare for further education and careers such as Game/Simulation Designer, Game Programmer, and Game Software Developer. Game and simulation design requires that students have a solid foundational understanding of game design, hardware, graphics, and animation. Persons with expertise in game and simulation design have had practical experiences in game/simulation conceptualization, design, storyboarding, development methodologies, essential programming techniques, working with a team, and implementation issues.

Sample occupations associated with this pathway:
♦ Game/Simulation Designer
♦ Game Programmer
♦ Game Software Developer
♦ Game Producer
♦ Multimedia Artist and Animator

D1.0 Identify and describe critical game and simulation studies, the resulting societal impact, and the management, industry, and career requirements.
  D1.1 Categorize the different gaming genres and gaming systems.
  D1.2 Describe the historical significance of electronic and nonelectronic games.
  D1.3 Describe the role of play in human culture.
  D1.4 Describe the psychological impact of games on individuals and groups.
  D1.5 Describe the business model commonly used in the game development industry.
  D1.6 Examine and categorize the significant processes in the production of interactive games.
  D1.7 Identify the core tasks and challenges that face a game or simulation design team.
  D1.8 Describe legal issues that affect games, developers and players.
  D1.9 Describe the impact of the game and simulation industry on the economy.

D2.0 Demonstrate an understanding of game and simulation analysis, design, standard documentation, and development tools.
  D2.1 Demonstrate an understanding of the vocabulary for discussing games and play by listing and describing the general procedure and requirements of game and simulation design.
  D2.2 Describe the game development life cycle.
  D2.3 Develop a game design document or blueprint.

D2.4 Understand the general principles of storytelling and the use of storyboarding in game design.

D2.5 Know how to use tools and software commonly used in game/simulation development and become familiar with popular game tools and different gaming engines.

D2.6 Demonstrate an understanding of the techniques used to evaluate game mechanics, game play, flow, and game design.

D2.7 Describe the complex interaction between games and players and the role it plays in the popularity of a game.

D2.8 Experience the methods used to create and sustain player immersion.

D2.9 Demonstrate an understanding of interface design, hardware constraints on games, including processors and I/O devices, and nonhardware constraints.

D2.10 Make informed decisions about game physics: how the game world works, how the players interact with the game world, and how the players interact with one another.

D3.0 Create a working game or simulation individually or as part of a team.

D3.1 Create a storyboard describing the essential elements, plot, flow, and functions of the game/simulation.

D3.2 Create a design specification document to include interface and delivery choices, rules of play, navigation functionality, scoring, media choices, start and end of play, special features, and development team credits.

D3.3 Using simple game development tools, create a game or simulation.

D3.4 Present the game or simulation.

D4.0 Identify, describe, and implement standard game/simulation strategy and rules of play.

D4.1 Understand strategic outlining in game designs.

D4.2 Know elements of puzzle design.

D4.3 Use key strategic considerations in game design.

D4.4 Understand the process of creating and designing player actions.

D4.5 Create and design the game flow as it relates to story and plot.

D4.6 Assess common principles and procedures in game flow design.

D4.7 Describe rule creation elements of player challenge.

D5.0 Integrate music, sound, art, and animation as it applies to the environmental design of the game/simulation.

D5.1 Understand the methodologies for integrating digital media into a game or simulation.

D5.2 Identify commonly used art and animation production tools in the game design industry.

D5.3 Understand the general concepts of environmental design.

D5.4 Describe how environmental design is used in conjunction with game level design.

D6.0 Explain the role and principles of event modeling and interface design and apply those principles in a game/simulation design and project.

D6.1 Define the meaning of simulation and pertinent issues facing game designers.

D6.2 Describe applied event modeling as it relates to game design.

D6.3 Identify and describe the basic Human Computer Interface (HCI) design principles.

D6.4 Apply the "eight golden rules" of interface design.

D6.5 Understand the use of inventory systems in game design.

D7.0 Acquire and apply appropriate programming skills for rendering a single player or multiuser game or simulation project, including program control, conditional branching, memory management, scorekeeping, timed event strategies, and implementation issues.

D7.1 Identify functions of information processing and describe basic network terminology and network security and demonstrate an understanding of operating systems, environments, and platforms.

D7.2 Plan program design and evaluate assigned game programming tasks.

D7.3 Code and test programs.

D7.4 Create and maintain documentation and perform program maintenance.

D7.5 Implement enhanced program structures.

D7.6 Implement multimedia programming.

D8.0 Acquire and apply appropriate artificial intelligence (AI) techniques used by the game development industry.

D8.1 Describe AI and how it relates to game and simulation design and development.

D8.2 Design, program, and implement intelligent agents for action games.

D8.3 Use AI techniques, like finite state machines, to produce the illusion of intelligence in the behavior of nonplayer characters (NPCs).

D8.4 Create intelligently designed games that would educate as well as engage the players.

Academic Alignment Matrix

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
ENGLISH LANGUAGE ARTS				
Language Standards – LS (Standard Area, Grade Level, Standard #)				
11-12.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.	A1.0, A2.0, A3.0, A4.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0
11-12.2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.	A1.0, A2.0, A3.0, A4.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0
11-12.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.	A1.0, A2.0, A3.0, A4.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0
11-12.4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 11–12 reading and content*, choosing flexibly from a range of strategies.	A1.0, A2.0, A3.0, A4.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0
11-12.5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.	A1.0, A2.0, A3.0, A4.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0
11-12.6. Acquire and accurately use general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	A1.0, A2.0, A3.0, A4.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0
Reading Standards for Information Text – RSIT (Standard Area, Grade Level, Standard #)				
11-12.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.	A5.0, A6.0, A7.0	B1.0, B5.0	C2.0, C4.0	D3.0
11-12.2. Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; provide an objective summary of the text.	A1.0, A5.0, A6.0, A7.0	B1.0, B5.0	C2.0,C4.0	D3.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
11-12.3. Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.	A1.0, A2.0, A4.0, A5.0, A6.0, A7.0	B4.0, B1.0, B5.0	C2.0, C4.0	D3.0
11-12.5. Analyze and evaluate the effectiveness of the structure an author uses in his or her exposition or argument, including whether the structure makes points clear, convincing, and engaging.		B1.0, B5.0, B8.0	C2.0, C4.0	D3.0
11-12.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.	A1.0, A3.0, A8.0	B1.0, B2.0, B4.0, B5.0, B7.0	C1.0, C2.0	D3.0
Writing Standards – WS (**Standard Area, Grade Level, Standard #**)				
11-12.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	A7.0		C2.0, C4.0, C5.0, C10.0	D2.0, D3.0
11-12.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.	A7.0	B1.0, B2.0, B3.0	C1.0, C2.0, C3.0, C4.0, C6.0, C7.0, C8.0, C9.0	D2.0, D3.0
11-12.3 Write narratives to develop real or imaged experiences or events using effective technique, well-chosen details, and well-structured event sequences.	A8.0, A7.0	B4.0	C2.0, C4.0, C6.0	D2.0, D3.0
11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	A1.0, A3.0, A7.0	B1.0, B2.0, B3.0, B4.0	C2.0, C4.0, C6.0	D2.0, D3.0, D7.0
11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.	A1.0, A7.0	B1.0, B2.0, B3.0, B4.0, B7.0	C2.0, C4.0, C6.0	D2.0, D3.0
11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.	A1.0, A2.0, A4.0, A6.0, A7.0	B1.0, B2.0, B3.0, B4.0	C2.0, C4.0, C6.0	D2.0, D3.0
11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	A1.0, A6.0, A8.0	B1.0, B2.0, B3.0, B4.0, B8.0	C2.0	D1.0, D3.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	**B.** Networking	**C.** Software and Systems Development	**D.** Games and Simulation
11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation including footnotes and endnotes.	A1.0, A3.0, A5.0, A6.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B8.0	C2.0, C4.0	D1.0, D2.0, D3.0
11-12.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.	A1.0, A6.0, A7.0, A8.0, A10.0		C2.0, C4.0, C6.0	D1.0, D2.0, D3.0
MATHEMATICS				
Algebra – A-CED – Creating Equations				
Create equations that describe numbers or relationships				
1. Create equations and inequalities in one variable including ones with absolute value and use them to solve problems in and out of context, including equations arising from linear functions. 1.1 Judge the validity of an argument according to whether the properties of real numbers, exponents, and logarithms have been applied correctly at each step. (CA Standard Algebra II - 11.2)	A8.0	B4.0, B7.0	C4.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0
2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.	A4.0, A8.0	B4.0, B7.0	C4.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0
3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.	A4.0, A8.0	B4.0, B7.0	C4.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0
4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law $V = IR$ to highlight resistance R.	A8.0	B4.0, B7.0	C4.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
Algebra – A-REI – Reasoning with Equations and Inequalities				
Understand solving equations as a process of reasoning and explain the reasoning				
1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.	A8.0	B4.0, B7.0	C4.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0
2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.	A8.0	B4.0, B7.0	C4.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0
Functions – F-IF – Interpreting Functions				
Understand the concept of a function and use function notation				
1. Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.	A4.0, A8.0	B4.0, B7.0	C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.	A4.0, A8.0	B4.0, B7.0	C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
3. Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. For example, the Fibonacci sequence is defined recursively by $f(0) = f(1) = 1, f(n+1) = f(n) + f(n-1)$ for $n \geq 1$.	A8.0	B4.0, B7.0	C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
Interpret functions that arise in applications in terms of the context				
4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.	A4.0, A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
5. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function $h(n)$ gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.	A4.0, A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
6. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.	A4.0, A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
Analyze functions using different representations				
7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. a. Graph linear and quadratic functions and show intercepts, maxima, and minima. b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. d. (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.	A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
8. Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. b. Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)^{12t}$, $y = (1.2)^{t/10}$, and	A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
classify them as representing exponential growth or decay.				
9. Compare properties of *two* functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.	A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
10. Demonstrate an understanding of functions and equations defined parametrically and graph them. (CA Standard Math Analysis - 7.0)	A8.0	B4.0, B7.0	C1.0, C4.0, C6.0, C10.0	D3.0, D4.0, D5.0, D6.0, D7.0
Functions – F-LE – Linear, Quadratic, and Exponential Models				
Interpret expressions for functions in terms of the situation they model				
5. Interpret the parameters in a linear or exponential function in terms of a context.	A8.0	B4.0, B7.0	C4.0, C5.0, C6.0	D3.0, D4.0, D5.0, D6.0, D7.0
6. Apply quadratic equations to physical problems, such as the motion of an object under the force of gravity. (CA Standard Algebra 1- 23.0)			C4.0, C6.0,	D3.0, D4.0, D5.0, D6.0, D7.0
Geometry – C – Circles				
Find arc lengths and areas of sectors of circles				
5. Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector.			C2.0, C4.0, C9.0	
Geometry – G-CO – Congruence				
Understand congruence in terms of rigid motions				
6. Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.			C2.0, C4.0, C9.0	
7. Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent.			C4.0, C9.0	

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
8. Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions.			C4.0, C9.0	
Make geometric constructions				
12. Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.			C2.0, C4.0	
Geometry – G-GMD – Geometric Measurement and Dimensions				
Explain volume formulas and use them to solve problems				
1. Give an informal argument for the formulas for the circumference of a Circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.			C4.0, C10.0	
2. (+) Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.			C4.0, C10.0	
3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.			C4.0, C10.0	
Visualize relationships between two-dimensional and three-dimensional objects				
4. Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three dimensional objects generated by rotations of two-dimensional objects.			C3.0, C5.0, C10.0	
5. Determine how changes in dimensions affect the perimeter, area, and volume of common geometric figures and solids.			C4.0	

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Geometry – G-GPE – Expressing Geometric Properties with Equations				
Use coordinates to prove simple geometric theorems algebraically				
4. Use coordinates to prove simple geometric theorems algebraically. For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that the point (1, √3) lies on the circle centered at the Origin and containing the point (0, 2).			C2.0, C4.0, C6.0, C9.0	D3.0, D4.0, D5.0, D6.0, D7.0
5. Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).			C2.0, C4.0, C6.0, C9.0	D3.0, D4.0, D5.0, D6.0, D7.0
6. Find the point on a directed line segment between two given points that partitions the segment in a given ratio.			C2.0, C4.0, C6.0, C9.0	D3.0, D4.0, D5.0, D6.0, D7.0
7. Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.			C2.0, C4.0, C6.0, C9.0	D3.0, D4.0, D5.0, D6.0, D7.0
Geometry – G-MG – Modeling with Geometry				
Apply geometric concepts in modeling situations				
1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder.	A3.0, A8.0	B1.0, B2.0, B3.0	C1.0, C2.0, C4.0, C5.0, C6.0, C9.0, C10.0	D2.0, D3.0, D4.0, D5.0, D6.0, D7.0
2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).				D2.0, D3.0, D4.0, D5.0, D6.0, D7.0
3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios)	A3.0, A8.0		C1.0, C2.0, C4.0, C5.0, C9.0, C10.0	D2.0, D3.0, D4.0, D5.0, D6.0, D7.0
Geometry – G-SRT – Similarity, Right Triangles, and Trigonometry				
Understand similarity in terms of similarity transformations				

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
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1. Verify experimentally the properties of dilations given by a center and a scale factor: a. A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged. b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.			C2.0, C4.0, C9.0	
2. Given two figures, use the definition of similarity in terms of similarity transformations to decide if they are similar; explain using similarity transformations the meaning of similarity for triangles as the equality of all corresponding pairs of angles and the proportionality of all corresponding pairs of sides. 3. Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.			C2.0, C4.0, C9.0	
3. Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.			C4.0, C9.0	
Numbers and Quantities – N-RN – The Real Number System				
Extend the properties of exponents to rational exponents				
1. Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. For example, we define $5^{1/3}$ to be the cube root of 5 because we want $(5^{1/3})^3 = 5^{(1/3)3}$ to hold, so $(5^{1/3})^3$ must equal 5.	A8.0	B4.0, B7.0	C1.0, C4.0	D7.0
2. Rewrite expressions involving radicals and rational exponents using the properties of exponents.	A8.0	B4.0, B7.0	C1.0, C4.0	D7.0
Use properties of rational and irrational numbers				
3. Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.			C1.0, C7.0, C8.0	

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
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Numbers and Quantities – N-Q – Quantities				
Reason quantitatively and use units to solve problems				
1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	A2.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0	C1.0, C4.0, C6.0	D2.0, D6.0
2. Define appropriate quantities for the purpose of descriptive modeling.	A2.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0	C1.0, C4.0, C6.0	D2.0, D6.0
3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	A2.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0	C1.0, C4.0, C6.0	D2.0, D6.0
Numbers and Quantities – N-CN – Complex Number System				
Represent complex numbers and their operations on the complex plane				
4. (+) Represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers), and explain why the rectangular and polar forms of a given complex number represent the same number.			C4.0, C6.0, C10.0	D5.0, D7.0, D8.0
5. (+) Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. For example, $(-1 + -\sqrt{3} i) = 8$ because $(-1 + -\sqrt{3} i)$ has modulus 2 and argument 120°.		B1.0, B2.0, B3.0	C4.0, C6.0, C10.0	D5.0, D7.0, D8.0
6. (+) Calculate the distance between numbers in the complex plane as the modulus of the difference, and the midpoint of a segment as the average of the numbers at its endpoints.			C4.0, C6.0, C10.0	D5.0, D7.0, D8.0
Number and Quantity – N-VM – Vector and Matrix Quantities				
Perform operations on matrices and use matrices in applications				
6. (+) Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network.	A8.0	B4.0, B7.0	C4.0, C7.0, C8.0	D6.0, D7.0
7. (+) Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled.	A8.0	B4.0, B7.0	C4.0, C7.0, C8.0	D6.0, D7.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
8. (+) Add, subtract, and multiply matrices of appropriate dimensions.	A8.0	B4.0, B7.0	C4.0, C7.0, C8.0	D6.0, D7.0
9. (+) Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.	A8.0	B4.0, B7.0	C4.0, C7.0, C8.0	D6.0, D7.0
10. (+) Understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. The determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse.	A8.0	B4.0, B7.0	C4.0, C7.0, C8.0	D6.0, D7.0
11. (+) Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors.	A8.0	B4.0, B7.0	C4.0, C6.0, C7.0, C8.0	D6.0, D7.0
12. (+) Work with 2 x 2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.	A8.0	B4.0, B7.0	C4.0, C6.0, C7.0, C8.0	D6.0, D7.0
Statistics and Probability – S-IC – Making Inferences and Justifying Conclusions				
Understand and evaluate random processes underlying statistical experiments				
1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.	A1.0, A8.0	B4.0, B6.0, B7.0	C2.0, C3.0, C4.0, C8.0	D1.0, D2.0, D4.0, D6.0, D7.0
2. Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?	A8.0	B4.0, B6.0, B7.0	C2.0, C3.0, C4.0, C8.0	D2.0, D4.0, D6.0, D7.0
Make inferences and justify conclusions from sample surveys, experiments, and observational studies				
3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.	A1.0, A2.0, A8.0	B4.0, B6.0, B7.0	C1.0, C2.0, C3.0, C4.0, C8.0	D1.0, D2.0, D4.0, D6.0, D7.0
5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.	A1.0, A2.0, A8.0	B4.0, B6.0, B7.0	C1.0, C2.0, C3.0, C4.0, C8.0	D1.0, D2.0, D4.0, D6.0, D7.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
6. Evaluate reports based on data.	A1.0, A2.0, A8.0	B4.0, B6.0, B7.0	C1.0, C2.0, C3.0, C4.0, C8.0	D1.0, D4.0, D6.0, D7.0
Statistics and Probability – S-ID – Interpreting Categorical and Quantitative Data				
Summarize, represent, and interpret data on a single count or measurement variable				
1. Represent data with plots on the real number line (dot plots, histograms, and box plots).	A8.0	B4.0, B7.0	C2.0, C3.0, C4.0, C6.0, C8.0	D1.0, D2.0, D4.0, D5.0, D6.0, D7.0
2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	A8.0	B4.0, B7.0	C2.0, C3.0, C4.0, C6.0, C8.0	D1.0, D2.0, D4.0, D5.0, D6.0, D7.0
3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).	A8.0	B4.0, B7.0	C2.0, C3.0, C4.0, C6.0, C8.0	D1.0, D2.0, D4.0, D5.0, D6.0, D7.0
4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.	A8.0	B4.0, B7.0	C2.0, C3.0, C4.0, C6.0, C8.0	D1.0, D2.0, D4.0, D5.0, D6.0, D7.0
Summarize, represent, and interpret data on two categorical and quantitative variables				
5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.	A8.0	B4.0, B7.0	C2.0, C3.0, C4.0, C6.0, C8.0	D1.0, D2.0, D4.0, D5.0, D6.0, D7.0

6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
    a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or chooses a function suggested by the context. Emphasize linear, quadratic, and exponential models.
    b. Informally assess the fit of a function by plotting and analyzing residuals.
    c. Fit a linear function for a scatter plot that suggests a linear association.
	A8.0	B4.0, B7.0	C2.0, C3.0, C4.0, C6.0, C8.0	D1.0, D2.0, D4.0, D5.0, D6.0, D7.0

Statistics and Probability – S-MD – Using Probability to Make Decisions				
Calculate expected values and use them to solve problems				
1. (+) Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0
2. (+) Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
3. (+) Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; find the expected value. For example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices, and find the expected grade under various grading schemes.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0
4. (+) Develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically; find the expected value. For example, find a current data distribution on the number of TV sets per household in the United States, and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0
Use probability to evaluate outcomes of decisions				
5. (+) Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values. a. Find the expected payoff for a game of chance. For example, find the expected winnings from a state lottery ticket or a game at a fast-food restaurant. b. Evaluate and compare strategies on the basis of expected values. For example, compare a high deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D7.0, D8.0
6. (+) Use probabilities to make fair decisions (e.g., drawing by lots, using a random number generator).	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D7.0, D8.0
7. (+) Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0
Statistics and Probability – APPS – Advanced Placement Probability and Statistics				
10. Students know the definitions of the mean, median and mode of distribution of data and can compute each of them in particular situations.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0
15. Students are familiar with the notions of a statistic of a distribution of values. of the sampling distribution of a statistic. And of the variability of a statistic.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
16. Students know basic facts concerning the relation between the mean and the standard deviation of a sampling distribution and the mean and the standard deviation of the population distribution.	A3.0, A4.0, A7.0, A8.0	B1.0, B2.0, B3.0, B4.0, B7.0, B8.0	C2.0, C4.0, C10.0	D1.0, D2.0, D7.0, D8.0
SCIENCE				
Life Sciences – LS				
LS1: From Molecules to Organisms: Structures and Processes				
LS1.A: Structure and Function	A3.0		C4.0, C10.0	D6.0, D7.0
LS1.B: Growth and Development of Organisms	A3.0		C4.0, C10.0	D6.0, D7.0
LS4: Biological Evolution: Unity and Diversity				
LS4.B: Natural Selection	A2.0		C4.0, C10.0	D6.0, D7.0
HISTORY/SOCIAL SCIENCE				
Principles of American Democracy and Economics – AD				
12.7 Students analyze and compare the powers and procedures of the national, state, tribal, and local governments.	A1.0, A5.0, A8.0	B7.0	C1.0, C2.0	D1.0
12.7.5. Explain how public policy is formed, including the setting of the public agenda and implementation of it through regulations and executive orders.	A1.0, A5.0			D3.0, D12.0
12.8 Students evaluate and take and defend positions on the influence of the media on American political life.	A3.0	B1.0, B4.0, B7.0	C6.0	D1.0, D5.0
12.8.2. Describe the roles of broadcast, print, and electronic media, including the Internet, as means of communication in American politics.	A1.0, A3.0	B1.0, B4.0, B7.0	C6.0	D1.0, D5.0
12.8.3. Explain how public officials use the media to communicate with the citizenry and to shape public opinion.	A1.0, A3.0	B1.0, B4.0, B7.0	C6.0	D1.0, D5.0

INFORMATION AND COMMUNICATION TECHNOLOGIES	PATHWAYS			
	A. Information Support and Services	B. Networking	C. Software and Systems Development	D. Games and Simulation
U.S. History and Geography – US				
11.8 Students analyze the economic boom and social transformation of post-World War II America.	A1.0, A8.0	B7.0	C1.0, C2.0	D1.0
11.8.7. Describe the effects on society and the economy of technological developments since 1945, including the computer revolution, changes in communication, advances in medicine, and improvements in agricultural technology.	A1.0, A8.0	B7.0	C1.0, C2.0	D1.0
World History, Culture, and Geography – WH				
10.3 Students analyze the effects of the Industrial Revolution in England, France, Germany, Japan, and the United States.	A1.0, A8.0		C1.0, C2.0	D1.0
10.3.5. Understand the connections among natural resources, entrepreneurship, labor, and capital in an industrial economy.	A1.0, A6.0, A8.0	B7.0	C1.0, C2.0	D1.0
10.9 Students analyze the international developments in the post-World World War II world.	A1.0, A6.0, A8.0	B7.0	C1.0, C2.0, C6.0	D1.0
10.11 Students analyze the integration of countries into the world economy and the information, technological, and communications revolutions (e.g., television, satellites, computers).	A1.0, A3.0, A8.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0	C1.0, C2.0, C4.0, C6.0, C10.0	D1.0

Appendix: CTE Model Curriculum Standards Contributors

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