Title: Robotics Engineering

Job Titles: Robotics Technicians (17-3024)
Electronics Engineering Technician (17-3023)
Electrical and Electronic Asembler (51-2022)
Electrical and Electronic Equipment Repairer
Machine Operator
Tool Programmer

Course Description:
The Robotics Engineering is a 900-hour course that trains students for post-secondary education and/or an entry-level position in a variety of related occupations, such as Robotics Technician, Machine Operator, Machinists, Tool Programmers, Computer Programmer, Computer Systems Analysis, and Robot Machine Operator.

The Introduction to Robotics Engineering Module (minimum 180 hours): Students will study the connection between applied physics principles and several branches of engineering: mechanical, computer, electronic, industrial, chemical, and materials. In addition, students will investigate the creation and use of robots in NASA exploration, industrial manufacturing, engineering design, hazardous duty, maintenance, firefighting, surgery, and military robots.

The Advanced Robotics Engineering Module (minimum 180 hours): Students will develop a deeper understanding of the topics taught in the introductory class as well as be introduced to more advanced engineering topics such as vision systems, neural networks, and multitasking robotic environments. Students will learn the manufacturing processes and design, engineering problem solving, new product development, and designing specifically for the disadvantaged.

This course is a rigorous hands-on, algebra-based, computer programming intensive, extensive reading and writing, research, and laboratory engineering program. Students may have an opportunity to compete at the For Inspiration and Recognition of Science & Technology (FIRST) competitions. Students compete as a team to solve an engineering design problem.

This course aligns with and incorporates the California Career Technical Education Model Curriculum Standards, Common Core Content Standards as reflected in the Academic Alignment Matrix, Standards for Career Ready Practice, Anchor Standards, and Pathway Standards.

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<tr>
<th>Module</th>
<th>Module Title</th>
<th>Classroom Hours</th>
<th>OJT (CC) Hours</th>
<th>OJT (CVE) Hours</th>
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<td>I</td>
<td>Career Ready Practice</td>
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<tr>
<td>II</td>
<td>Introduction to Robotics Engineering</td>
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<td>III</td>
<td>Advanced Robotics Engineering</td>
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<td><strong>Total Hours:</strong></td>
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<td><strong>630</strong></td>
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Revised 2014-2015
## Course Title
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Classroom Physical Environment
The classroom setting requires both a fully equipped workshop with equipment, tools, and supplies in sufficient quantity to train the number of students assigned to each instructor. This facility must be equipped with adequate lighting and many electrical outlets (at least one outlet per every two students plus four additional).

- NOTE: This class should be conducted in a site that simulates an industry-standard workplace in this field.

Minimal Requirements
Flat student desks or worktables, teacher’s desk and chair, whiteboard or chalkboard, file cabinet, locked cabinets for storage, computer tables, computers, Internet, printer, document camera, projector, DVD player, screen.

Equipment and Materials

Hand Tools:
- Various size Phillips screwdrivers
- Various size flathead screwdrivers
- Wire cutter
- Wire stripper
- Pliers
- Hex key set
- Measuring tape
- Vice grips
- Flat and curved metal files
- Hacksaw
- Metal punch
- Pry bar
- Various large and small clamps
- Heavy-duty workbench vice

Power Tools:
- Variable speed sabre saw
- Portable drill
- Reciprocating portable saw
- Portable grinder
- Stationary grinder / steel brush
- Belt / disc sander
- Drill press
- Portable circular saw

Electronic Equipment:
- PC compatible computers with serial port
- Parallax BOE-BOT (1 per 2–4 students)
- Parallax Toddler (1 per 2–4 students) – Advanced Robotics
- Javelin microcontroller (1 per 2–4 students) – Advanced Robotics
- Radio Shack Electronic Learning Lab (1 per 2–4 students)
- Robotics arm with PC interface and software – Advanced Robotics
- Introduction to Robotics VexRobotics Classroom and Competition Super Kit P/N: 276-3000
- Advanced Robotics, FIRST Robotics Competition Kit of Parts
- Multimeter
- Electrical components
- Extension cords
- Flashlight
- AA batteries

**Miscellaneous Supplies:**
- Workbench
- Tool chest
- Discs for portable grinder
- Protective goggles
- Protective gloves
- 4 foot metal ruler
- Protective earphones
- Vice for drill press
- Clamp for drill press
- Attachments for portable drill (screwdrivers, nut drivers etc.)
- Various size drill bits
- Cobalt drill bit set
- Various size wood/metal blades for sabre saw
- Various size wood/metal blades for reciprocating saw
- Various number of teeth blades for band saw
- Various blades for circular saw (wood and metal cutting)
- Metal scribe (marking tool)
- Various size nuts/bolts/metal screws

**Operational Methodologies**

- **Classroom (C):** Instruction provided by a qualified teacher, utilizing a lesson plan, to a group of students in a classroom.
- **Community Classroom (CC):** An instructional method which utilizes unpaid, on-the-job training experiences at business, industry, and public agency sites.

California Career Technical Education Model Curriculum Standards, Grades 7-12
Industry Sector Anchor Standards (AS): Engineering and Architecture
Pathway Standards (PS): Engineering Technology (B)
Standards for Career Ready Practice (CRP):
Common Core State Standards (CCSS): Language Arts (ELA); Mathematics (M)
• **Cooperative Vocational Education (CVE):** An instructional method which correlates concurrent, formal vocational classroom instruction with regularly scheduled, paid on-the-job training experience.

• **Related Instruction (RI):** Classroom instruction and unpaid/paid on-the-job training experiences are being conducted together within the same time frame (quarter, semester, etc.).

• **On-the-Job Training (OJT):** Refers to “hands-on” job skill training in either the community classroom (unpaid) or in correlation with cooperative vocational education (paid).

### Training OJT Environment
Title 5 Education Code No. 10085
The following criteria shall be used to select and approve a community classroom training station:

(a) The management of the community classroom training station shall:
   1. Have a clear understanding of the community classroom methodology and a willingness to participate in the training experience.
   2. Cooperate with the career technical education director, or his/her designee, in preparing a written joint venture agreement.
   3. Participate with the community classroom teacher in preparing an individualized training plan.
   4. Provide and assist students with unpaid on-the-job training experiences as described in the individualized training plan.
   5. Consult with the community classroom teacher regarding the student’s progress during the unpaid on-the-job training experiences.
   6. Assist in maintaining accurate records of the pupils training hours.

(b) The training station shall offer training opportunities in the specific occupation for which the course is approved. Training opportunities at the station shall expand competencies developed in the classroom instruction portion of the student’s training.

(c) The training station shall have adequate equipment, materials, and other resources to provide an appropriate learning opportunity.

(d) Training station conditions shall prevail which will not endanger the health, safety, welfare, or morals of the pupil.

(e) The training station shall be concurrently engaged in a business operation, which requires employment in the occupation for which training is provided.

Ed. Code Title 5 10107
(a) The employer at the cooperative career technical training station shall:
   1. Have a clear understanding of program objectives and a willingness to participate in the program.
   2. Provide adequate supervision to ensure a planned program of the students’ paid on-the-job training in order that the student may receive maximum education benefit.
   3. Consult with the cooperative career technical education teacher regarding the paid on-the-job progress of the student.
   4. Cooperate with the career technical education direction or his or her designee in preparing a written training agreement.
(5) Participate with the cooperative career technical education teacher and the student in preparing an individualized training plan.
(6) Provide a minimum of 8 hours of paid employment per week to assist students to acquire those competencies necessary for employment and advancement in the occupational area for which training offered.
(7) Assist in maintaining accurate records of the students’ training hours.
(8) Provide Workers’ Compensation Insurance for students employed through the Cooperative Career Technical Education Program.

(b) The training station shall offer training opportunities in the specific occupation for which the course is approved. Training opportunities at the paid station shall be in the occupation for which related instruction is provided.
(c) Training station working conditions shall not endanger the health, safety, welfare or morals of the students.
(d) The training station shall have adequate equipment, materials and other resources to provide an appropriate learning opportunity.

**Instructional Methodologies, Strategies and Techniques**

A variety of instructional methodologies, strategies, and techniques are used to instruct the students. These include, but are not limited to the following:
- Teacher modeling
- Lecture and guided practice
- Class discussions
- Demonstration
- Assigned readings from tutorials, textbooks, periodicals, journals, etc.
- Hands-on activities
- Laboratory activities which emphasize open-ended hands-on exploration and investigation
- Team and subspecialty teamwork
- Individual instruction
- Personal journals
- Possible field trips to Cal Tech, JPL, and/or a manufacturing and/or electronics company
- Independent and group research projects
- Independent and group engineering projects
- Collaboration with community, corporate, and/or JPL mentors
- Work-based learning experiences
- Guest speakers
- Enrichment videos and slide presentations
- Student presentations and assignments (oral, written, technological)
Utilization of computers/technology

Assessment of Student Performance
Assessment of student performance may include but is not limited to:
- Student portfolios
- Student demonstrations
- Individual and group presentations
- Supervisor/teacher observations
- Peer evaluations
- Self-reflections
- Critiques
- Rubrics
- Oral assessment
- Reports and research papers
- Individual and group projects
- Substantial written assignments
- Problem-solving activities
- Participation in engineering design sessions
- Engineering design and building projects
- Accomplishment of specific goals in team and subspecialty teamwork
- Tests and quizzes
- Performance tasks

Students will be assessed in multiple ways to ensure that a variety of learning styles are addressed.

Safety
- All students will successfully complete a safety exam with results kept on file.
- Specialized safety needs related to tools and supplies used.

Recommended Supplemental Instructional Textbooks
- Robotics Technology by James W. Masterson – Introduction to Robotics
- Robotics Technology: Laboratory Manual by James W. Masterson – Introduction to Robotics
- Carnegie Mellon Robotics Academy for VEXRobotics
- The VEX EDR Curriculum
Magazines and Scientific Journals
- Popular Electronics
- Microcomputer Journal
- Nuts & Volts
- Scientific American
- Electronic Design
- Robotics Research

Reference Books
- Robotics! Student Workbook (Parallax)
- The Basic Stamp User’s Manual (Parallax) – Introduction to Robotics
- Advanced Robotics Student Workbook (Parallax) – Advanced Robotics
- Javalin User’s Manual (Parallax) – Advanced Robotics
- The Basic Stamp User’s Manual (Parallax)
- Engineer’s Notebooks
- Engineering “Cookbooks”
- The Robot Builder’s Bonanza
- The How and Why of Mechanical Movement
- Sensors for Mobile Robots
- Navigating Mobile Robots
- Handbook of Physics
- Practical Robotics: Principles and Applications by Bill Davies
- Robot Technology Fundamentals by James G. Keramas

Special Instructor(s) Prerequisites
- Valid California Designated Subjects credential authorizing CTE teaching in the industry sector identified.
- Knowledge of current industry trends and practices, including appropriate technology.
- Willingness to establish local community work sites and ability to access resources.
- Willingness to participate in advisory and committee meetings, including recruiting and collaborating with business partners.
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<tr>
<th><strong>INSTRUCTIONAL CONTENT</strong></th>
<th><strong>STUDENT OUTCOMES</strong></th>
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<td>1. CAREER READY PRACTICE</td>
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<td>Introduction to CTE</td>
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<td>Explain the “Drivers of Change” and how it relates to college and career.</td>
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<td>C. Technical Skills and</td>
<td>Apply appropriate</td>
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<td>Analyze and apply</td>
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<td>appropriate academic standards required for successful industry sector pathway completion leading to postsecondary education and employment.</td>
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<td>D. Communication Skills</td>
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<td><strong>I. CAREER READY PRACTICE (Continued)</strong></td>
<td>communication.</td>
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<td>• Describe issues related to communicating in a global society.</td>
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<td>• Explain the appropriate etiquette for answering telephone calls and leaving voicemail messages; receiving and making requests; giving directions and persuading others.</td>
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<td>• Identify the steps to plan a successful oral presentation.</td>
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<td>• Develop an education and career plan aligned with personal goals.</td>
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<td>• Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. <strong>AS 3.0</strong></td>
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<td>• Apply the decision-making process to develop a college and career plan. <strong>AS 5.0</strong></td>
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<td>• Identify employability skills required for participation in the world of work.</td>
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<td>• Assess interests, skills and aptitudes and match these to career options.</td>
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<td>• Identify further education and/or training needed for career choices.</td>
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<td>• Develop a resume, cover letter and other resources for the job search process.</td>
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<td>• Complete a job application.</td>
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<td>• Identify what employers are looking for when hiring employees.</td>
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<td>• Apply effective interviewing skills and write a thank-you note.</td>
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<td></td>
<td>• Create a career portfolio that links to future college and career options.</td>
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California Career Technical Education Model Curriculum Standards, Grades 7-12
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<tr>
<td>I. CAREER READY PRACTICE (Continued)</td>
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</table>
| F. Technology | - Apply technology to enhance productivity. *CRP 4*
- Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments and information. *AS 4.0; AS 10.0*
- Explain the role technology plays in the workplace.
- Describe the laws and licenses that govern the use of technology at school and in the workplace.
- Compare different types of media (word processing, digital media software, and video, audio) in relation to effectively communicating messages.

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<tr>
<th>G. Critical Thinking and Problems Solving Skills</th>
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</table>
| - Utilize critical thinking to make sense of problems and persevere in solving them. *CRP 5*
- 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, and synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *AS 5.0*
- Identify everyday strategies to build the capacity for critical thinking and school and the workplace.
- Explain the problem-solving process, including identifying the root cause of a problem, generating and considering possible solutions, choosing the best solution, and evaluating outcomes.

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<tr>
<th>H. Personal Health and Financial Literacy</th>
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</table>
| - Practice personal health and understand financial literacy. *CRP 6*
- Identify factors related to a person’s well-being.
- Analyze the relationship between personal health and workplace standards. |
## INSTRUCTIONAL CONTENT

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</table>
| **I. CAREER READY PRACTICE (Continued)** | performance.  
- Explain the relationship between stress and aggressive behavior.  
- Identify ways to lower the level of stress.  
- Use critical thinking and communication skills to manage conflict.  
- Develop potential living expenses and a budget based on income and needs.  
- Understand the responsible use of financial institutions and services (e.g. checking, savings, ATM, credit cards, investments, retirement, etc.).  
- Recognize that financial literacy and responsibility leads to a secure future and career success. | RI | OJT | RI | OJT |
| **I. Responsible Citizenship** | Act as a responsible citizen in the workplace and the community.  
- *CRP 7*  
  - Explain what the school, workplace and community expects of a student as a member of society.  
  - Identify personality and behavior characteristics that have a positive or negative impact at school, in the workplace, and in the community.  
  - Analyze the impact of an individual’s decision on others and on the environment, and recognize both short and long term consequences of actions.  
  - Identify areas in which sensitivity is required in a diverse workplace. |  |
| **J. Integrity, Ethical Leadership, and Effective Management** | Model integrity, ethical leadership, and effective management.  
- *CRP 8*  
  - Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the work.  
  - AS 8.0  
  - Define integrity and how it relates to the classroom and workplace. |  |
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<tr>
<td>I. CAREER READY PRACTICE (Continued)</td>
<td>• Identify characteristics of ethical behavior and leadership. • Compare and contrast the three basic management styles: authoritarian, democratic, and laissez faire.</td>
<td>RI</td>
<td>OJT</td>
<td>RI</td>
</tr>
<tr>
<td>K. Human Relations in the Workplace</td>
<td>• Work productively in teams while integrating cultural and global competence. <em>CRP 9</em> • Define human relations. • Explain the need for effective human relations skills at school and in the workplace. • Contrast the characteristics and consequences of positive and negative attitudes. • Recognize the contributions of diversity in society and in the workplace. • Assess the value of teamwork in the classroom and workplace. • Identify strategies that can be used to promote good working relationships within the classroom and in the workplace. • Explain the importance of networking. • Identify verbal, non-verbal, and physical types of harassment as defined by the state/federal law and determine appropriate behavior in the workplace.</td>
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<tr>
<td>L. Creativity and Innovation</td>
<td>• Demonstrate creativity and innovation. <em>CRP 10</em> • Identify how new ideas, thinking, tasks, solutions, and methods can be fostered in the workplace. <em>AS 5.0</em> • Explain the appropriate and constructive expression of creativity and innovation at school and in a workplace situation.</td>
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<tr>
<td>M. Research Strategies</td>
<td>• Employ valid and reliable research strategies. <em>CRP 11</em> • Define plagiarism. • Identify strategies for conducting basic research. • Explain resources for gathering information on a topic.</td>
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</table>
### INSTRUCTIONAL CONTENT

#### I. CAREER READY PRACTICE (Continued)

#### N. Decision-Making

- Explain how to confirm the validity of sources.
- Understand the environmental, social, and economic impacts of decisions. **CRP 12**
- Work with peers to promote civil, democratic discussions and decision making; set clear goals and deadlines; and establish individual roles as needed. **AS 9.0**
- Explain the decision-making process

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<td>- Work with peers to promote civil, democratic discussions and decision making; set clear goals and deadlines; and establish individual roles as needed. <strong>AS 9.0</strong></td>
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## II. INTRODUCTION TO ROBOTICS ENGINEERING

### A. History of Robotics
1. Introduction to the Field of Mechatronics
2. Robotic Terminology
3. Asimov’s Three Laws of Robotics
5. Technology History
6. Robot Generations
7. Cultural Differences Affecting Robot Design and Acceptance

- Interpret and explain terminology and practices specific to the Engineering and Architecture sector. *AS 10.1*
  - Understand the historical developments in electricity and electronics.
  - Create a timeline that depicts developments in technology.
  - Explain the major events of historical developments as they relate to current technology.

- Demonstrate elements of written and electronic communication, such as accurate spelling, grammar, and format. *AS 2.4*
- Research past, present, and projected technological advances as they impact a particular pathway. *AS 4.5*
  - Complete a research project: History of Robotics.

- Advocate and practice safe, legal, and responsible use of digital media information and communications technologies. *AS 2.6*
- Explore issues of global significance and document the impact on the Engineering and Architecture sector. *AS 7.8*
- Respect individual and cultural differences and recognize the importance of diversity in the workplace. *AS 9.7*

### B. Applications for Robotics Technology
1. NASA Exploration
2. Industrial Manufacturing
3. Engineering Design
4. Security and Surveillance
5. Search and Rescue

- Research past, present, and projected technological advances as they impact a particular pathway. *AS 4.5*
  - Understand that present and future application for robotics technology have a wide range including scientific, medical, defense, rescue, production, manufacturing, transportation, and entertainment.
  - Research several applications and report on one specific...
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<tr>
<td>6. Mining</td>
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<tr>
<td>8. The Role of Robots in Manufacturing</td>
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<td>9. Decision, repetition, and tedium</td>
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<tr>
<td><strong>C. Overview of Engineering – Major Fields of Engineering</strong></td>
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</tr>
<tr>
<td>1. Mechanical: Pumps, Gears, Hydraulics, Engines, Robotics, Ship/submersibles, Aerospace, Rube Goldberg</td>
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<td></td>
<td>• Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment. <em>AS 5.3</em></td>
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<td>○ Understand that engineering is solving problems by applying principles of mathematics, science, and technology.</td>
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<td>• Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate. <em>AS 5.2</em></td>
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<td>○ Solve programs using common engineering practices.</td>
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<td>○ Describe robotics technology applications including those for: scientific, medical, defense, rescue, production, manufacturing, transportation, service, and entertainment purposes.</td>
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<td>○ Explain why application characteristics and requirements may lead to the use of robotics technology rather than human labor.</td>
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## II. INTRODUCTION TO ROBOTICS ENGINEERING (Continued)

2. Electrical: Theory, Measurement, Control and Applications of Electrical Energy; Transistors, Motors, and Digital Devices; Interpret Schematics and Set-up Experimental Apparatuses; Make Measurements, Test Circuits, and Record Results


4. Industrial

5. Hardware

6. Software


8. Functions of Engineers in Each Field

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<tr>
<td>Engineering and Architecture sector. \textit{AS 10.1}</td>
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<tr>
<td>\textbullet{} Understand the major fields of engineering and with the diverse work functions that engineers perform.</td>
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<tr>
<td>\textbullet{} Explore the relatedness between mechanical, computer, electronic, industrial, chemical, and materials engineering.</td>
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<td>\textbullet{} Select several major fields of engineering and give a brief description of each.</td>
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<tr>
<td>\textbullet{} Describe how the technological fields of mechanics, electronics, controls, and computers, intersect.</td>
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<td>\textbullet{} Explain the importance of personal integrity, confidentiality, and ethical behavior in the workplace. \textit{AS 8.4}</td>
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<td>\textbullet{} Understand that engineers have a moral obligation to the public.</td>
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<td>\textbullet{} Research the scope of career opportunities available and the requirements for education, training, certification, and licensure. \textit{AS 3.4}</td>
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<tr>
<td>\textbullet{} Familiar with the paths and certifications that can lead to careers in engineering and engineering technology.</td>
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<td>\textbullet{} List several functions an engineer might perform in a particular industry.</td>
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<td>\textbullet{} Describe the level of education typically required to be an engineer or engineering technician.</td>
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<tr>
<td>\textbullet{} Investigate science and technology careers, as well as university programs in mechatronics, engineering, marketing, and business administration as they relate to robotics and engineering.</td>
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| D. Units of Measure  | • Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance. *PS B7.0*  
  o Understand the use of electronic test equipment and units of measure.  
  • Use tools, fasteners, and joining systems employed in selected engineering processes. *PS B7.3*  
  o Select and apply appropriate equipment or tools.  
  • Calibrate precision measurement tools and instruments to measure objects. *PS B7.6*  
  o Analyze and apply observed measurements. |
| 1. Units             | |
| 2. Unit Conversion   | |
| 3. Fundamental Physical Parameters | |
| E. Mathematics for Robotics | • Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment. *AS 5.3*  
  o Understand the mathematical processes and applications that lead to solutions of electronic problems.  
  • Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits. *PS B3.2*  
  • Understand the characteristics of alternating current (AC) and how it is generated; the characteristics of the sine wave; and of AC, tuned, and resonant circuits; and the nature of frequency spectrum. *PS B3.1*  
  • Calculate loads, currents, and circuit-operating parameters. *PS B3.5*  
  o Solve Direct-Current (DC) circuit analysis problems using |
| 1. Displacement      | |
| 2. Velocity          | |
| 3. Acceleration      | |
| 4. Projectile Motion | |
| 5. Forces            | |
| 6. Newton’s 3 Laws of Motion | |
| 7. Law of Gravity    | |
| 8. Ohm’s Law         | |
| 9. Resistance and Capacitance | |

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<td></td>
<td>o Calculate fundamental Alternating Current (AC) parameters.</td>
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<td>o Manipulate scientific notation in problem solutions.</td>
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<td>o Derive algebraic equations to determine unknown values in circuits.</td>
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<td>o Utilize a scientific calculator as a tool for problem solving.</td>
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<td>• Solve multi-step problems including word problems using linear equations in one variable.</td>
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## F. Science of Electricity and Electronics

1. Atomic Structure
2. Elements and the Periodic Table
3. Electrical Charges
4. Conduction
5. Insulation
6. Energy Conversion

- Determine what information and principles are relevant to a problem and its analysis. *PS B6.2*
  - o Understand the fundamental scientific principles involved in electricity and electronics.
  - o Describe the relationships between atomic structure of the atom, electricity, electronics, and the periodic table of elements.
  - o Define the Laws of Charges.
  - o Explain electron flow as it occurs in semiconductor materials.

## G. Electronic Components

1. Electronic Symbols
2. Electronic Components
3. Resistor Values
4. Color Coding

- Classify and use various electrical/electronic components, symbols, abbreviations, media, and standards of electrical drawings. *PS B3.6*
  - o Discern characteristics of commonly used electronic components.
  - o Identify symbols and component characteristics.
  - o Determine resistor’s values by identifying color codes.
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</table>
| H. Circuits and Measurement Tools | • Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits. *PS B3.2*  
  • Calculate, construct, measure, and interpret both AC and DC circuits. *PS B 3.3*  
    o Measure current, voltage and resistance in various segments of parallel and series circuits.  
  • Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems. *PS B5.0*  
  • Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems. *PS B5.5*  
    o Conduct laboratory experiments, which include detailed problem, theory, results, and discussion sections: including the use of lab equipment for measurement.  
    o Determine what information and principles are relevant to a problem and its analysis. *PS B6.2* |
|   1. Ohm’s Law | |
|   2. AC/DC | |
|   3. Voltage | |
|   4. Power Relationships | |
|   5. Transmission of Energy | |
|   6. Series and Parallel Circuits | |
|   7. Resistors and Capacitors | |
|   8. Diodes and Transistors | |
|   9. Lab Equipment:  
    Multimeters, Power Supplies, Measuring Tape | |
|  10. Electronic Learning Lab | |
| I. Electronic Assembly | • Interpret and explain terminology and practices specific to the Engineering and Architecture sector. *AS 10.1*  
  • Understand the procedures and processes related to electronic assembly.  
    o Identify tools commonly used in the electronic assembly.  
  • Construct projects and products specific to the Engineering and Architecture sector requirements and expectations. *AS 10.3*  
    o Construct an electronic device following a schematic diagram |
<p>|   • Schematic Diagrams | |
|   • Assembly Tools | |
|   • Electronic Assembly Skills | |
|   • Electronic Learning Lab | |</p>
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| II. INTRODUCTION TO ROBOTICS ENGINEERING (Continued) | as a sole reference.  
  o Use tools for their intended applications perform electronic assembly work such as: soldering, stripping/crimping wire, routing wires, making wiring harnesses, and rendering electrical/electronic layouts.  
  • Use methods and techniques for employing all engineering technology equipment appropriately. *PS B10.1*  
  • Apply conventional engineering technology process and procedures accurately, appropriately, and safely. *PS B10.2*  
  • Apply the concepts of engineering technology to the tools, equipment, projects, and procedures of the Engineering Technology Pathway. *PS B10.3* |
| J. Manufacturing | • Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance. *PS B7.0*  
  • Know the structure and processes of a quality assurance cycle. *PS B7.1*  
  • Describe the major manufacturing processes. *PS B7.2*  
  • Identify and demonstrate the use of common hand tools and fasteners. (PS D6.3)  
  • Estimate and measure the size of objects in both Standard International and United States units. *PS B7.4*  
  o Measure with precision measurement tools and instruments.  
  • Research past, present, and projected technological advances as they impact a particular pathway. *AS 4.5*  
  o Complete a research project: Industrial Survey. |

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#### K. Materials
1. Electronic Packaging
2. Integrated Circuit Manufacture
3. Sensors
4. Common Building Materials
5. Physical Properties of Materials
6. Selecting Materials Based on Characteristic and Design Requirements

#### L. Design Process/Problem Solving
1. Steps of the Engineering Design Process
2. Mission Statements
3. Requirements and Constraints
4. System Engineering Methods
5. System Design Drivers
6. Product Design Specifications
7. System Requirements

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<td>1. Electronic Packaging</td>
<td>• Interpret and explain terminology and practices specific to the Engineering and Architecture sector. <em>AS 10.1</em></td>
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<tr>
<td>2. Integrated Circuit Manufacture</td>
<td>o Understand material classifications, characteristics, and testing in order to select appropriate materials for engineering products.</td>
</tr>
<tr>
<td>4. Common Building Materials</td>
<td>o Compare and contrast the physical properties of specific materials.</td>
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<tr>
<td>5. Physical Properties of Materials</td>
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<tr>
<td>6. Selecting Materials Based on Characteristic and Design Requirements</td>
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<tr>
<td><strong>L. Design Process/Problem Solving</strong></td>
<td></td>
</tr>
<tr>
<td>1. Steps of the Engineering Design Process</td>
<td>• Understand the steps in the design process. <em>PS B6.1</em></td>
</tr>
<tr>
<td>2. Mission Statements</td>
<td>o Outline the steps in the design process.</td>
</tr>
<tr>
<td>3. Requirements and Constraints</td>
<td>• Determine what information and principles are relevant to a problem and its analysis. <em>PS B6.2</em></td>
</tr>
<tr>
<td>4. System Engineering Methods</td>
<td>• Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution. <em>PS B6.3</em></td>
</tr>
<tr>
<td>5. System Design Drivers</td>
<td>• Translate word problems into mathematical statements when appropriate. <em>PS B6.4</em></td>
</tr>
<tr>
<td>6. Product Design Specifications</td>
<td>• Demonstrate the process of developing multiple details, within design constraints, into a single solution. <em>PS B6.5</em></td>
</tr>
<tr>
<td>7. System Requirements</td>
<td>• Communicate and interpret information clearly in industry-standard visual and written formats. <em>PS B1.0</em></td>
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<td>o Select and finalize the solutions and complete a working</td>
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| 8. Literature Search | • Construct a prototype from plans and test it. *PS B6.6*  
- Use appropriate materials, tools, and processes to fabricate a model (form) of the solution.  
- Test model as appropriate. |
| 9. Performance, Cost, and Reliability | • Evaluate and redesign a prototype on the basis of collected test data. *PS B6.7*  
- Develop a working model (function) and/or prototype. |
| 10. Selection of Subsystems | • Collaborate with industry experts for specific technical knowledge and skills. *AS 10.4*  
- Understand the process of product development. *PS B9.1*  
- Disassemble an existing design to understand construction details.  
- Prepare a thorough technical documentation of a conceptual design.  
- Develop supporting text, data, and diagrams for a design presentation.  
- Prepare a three-view drawing of the design showing the subsystem layout. |
| 11. CAD/CAM | • Give an effective oral presentation of a portfolio/project. *PS B11.2*  
- Participate in the delivery of the final design presentation to fellow students and invited guests.  
- Develop a binder or digital portfolio representative of student work for presentation. *PS B11.2*  
- Complete a design project: Your Personal Robot |
| 12. Design Portfolios: Specifications, Systems Descriptions, Results, Analyses, and Drawings | • Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems. *PS B5.0*  
- Evaluate how energy is transferred and predict the effects of resistance in mechanical, electrical, fluid, and thermal systems. *PS* |
| 13. Reverse Engineering | |
| 14. Design Project Documentation | |
| M. Engineering Systems | |

California Career Technical Education Model Curriculum Standards, Grades 7-12  
Industry Sector Anchor Standards (AS): Engineering and Architecture  
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### II. INTRODUCTION TO ROBOTICS ENGINEERING

(Continued)

2. Force, Work, Rate, Power, Energy, and Resistance
3. Analog and Digital Systems
4. Safety Devices
5. AC/DC Systems

#### N. Robot Systems

1. Power
2. Controller
3. Actuators
4. Drive
5. Sensors
6. Transducers

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<tr>
<th>INSTRUCTIONAL CONTENT</th>
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</table>
| **B5.4**              | • Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal systems. **PS B5.5**
|                       | o Use appropriate electrical units to solve problems. **PS B5.5**
|                       | • Understand the concepts of physics that are fundamental to engineering technology. **PS B4.0**
|                       | o Apply Ohm's Law. **PS B4.0**
|                       | • Interpret and explain terminology and practices specific to the Engineering and Architecture sector. **AS 10.1**
|                       | o Give a physical description of inductors and capacitors and describe how they function. **AS 10.1**
|                       | o Identify the difference between analog and digital signals. **AS 10.1**
|                       | o Describe the function of a safety device. **AS 10.1**
|                       | o Identify what causes resistance in a fluid system. **AS 10.1**
|                       | o Give examples of hydraulic and pneumatic systems. **AS 10.1**
|                       | • Calculate, construct, measure, and interpret both AC and DC circuits. **PS B3.3**
|                       | o Identify series, parallel, and combination circuits. **PS B3.3**
|                       | o Give examples of common AC and DC systems. **PS B3.3**
|                       | • Draw flat layouts of a variety of objects by using the correct drafting tools, techniques, and media. **PS B1.3**
|                       | o Draw a circuit diagram and layout the circuit. **PS B1.3**
|                       | • Identify the elements and processes necessary to develop a controlled system that performs a task. **PS B8.1**
|                       | • Assemble input, processing, and output devices to create controlled systems capable of accurately completing a preprogrammed task. **PS B8.6**
|                       | o Identify, understand the function of, manipulate, and assemble commonly used electromechanical components into...
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>II. INTRODUCTION TO ROBOTICS ENGINEERING (Continued)</td>
<td>a comprehensive robot system.</td>
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<tr>
<td>7. Motors</td>
<td>o Build an electromechanical system – Robot (major group engineering project).</td>
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<tr>
<td>8. Relays</td>
<td>• Determine what information and principles are relevant to a problem and its analysis. PS B6.2</td>
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<tr>
<td>9. Solenoids</td>
<td>o Exam the mathematical similarities of electronics, hydraulics, and mechanics.</td>
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<tr>
<td>10. Cylinders</td>
<td>• Predict the effects of circuit conditions on the basis of measurements and calculations of voltage, current, resistance, and power. PS B3.8</td>
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<tr>
<td>11. Movement Systems</td>
<td>o Determine current, voltage and logic of a given system.</td>
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<tr>
<td>12. Electromechanical Systems</td>
<td>• Demonstrate use of sensors for data collection and process correction in controlled systems. PS B8.2</td>
</tr>
<tr>
<td>13. AC/DC Electrical Systems</td>
<td>• Perform tests, collect data, analyze relationships, and display data in a simulated or modeled systems using appropriate tools and technology. PS B8.3</td>
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<tr>
<td>14. Hydraulic/Pneumatic Power Systems</td>
<td>o Write a block diagram for a given system detailing the control logic of the circuit and its effect on the mechanical portion of the system.</td>
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<tr>
<td>15. Work Envelope</td>
<td>• Use motors, solenoids, and similar devices as output mechanisms in controlled systems. PS B8.5</td>
</tr>
<tr>
<td>16. Maintenance of Robotics Systems</td>
<td>• Communicate information and ideas effectively to multiple audiences using a variety of media and formats. AS 2.5</td>
</tr>
<tr>
<td>17. Robotics Sensing Systems</td>
<td>o Give a detailed presentation on an electromechanical system using presentation tools available in industry such as Microsoft PowerPoint.</td>
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<td>18. Tactile, Proximity, and Photoelectric Sensors</td>
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<td>19. Limit Switches</td>
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<tr>
<td>20. End of Arm Tooling</td>
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<td>21. Energy Conversion</td>
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<td>22. Energy Storage</td>
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<td>23. BOE-BOT</td>
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## II. INTRODUCTION TO ROBOTICS ENGINEERING (Continued)

### O. Control Systems

1. Semiconductor Devices
2. Software
3. Programming
4. BOE-BOT
5. Input/output
6. Memory
7. Digital Electronics
8. Programmable Logic Controllers
9. Monitoring Devices
10. Microprocessors
11. Control Software
12. Robot Interfacing
13. The Future of Robotics

- Understand fundamental control system design and develop systems that complete preprogrammed tasks. *PS B8.0*
- Program a computing device to control systems or process. *PS B8.4*
  - Write, store, edit, and analyze programs for control of electromechanical devices.
  - Convert numbers from base ten to binary and be able to perform simple arithmetic based on the binary, octal, and hexadecimal number systems.
  - Predict the output of systems which have AND, NOT, OR, NOR, NAND, and XOR operations.
  - Construct truth tables and use them to solve logic problems.
- Interpret and explain terminology and practices specific to the Engineering and Architecture sector. *AS 10.1*
  - Explain the fabrication process used to make integrated circuit chips.
  - Describe the use of computers in the following areas: interfacing to systems, data acquisition, and microcomputers in control systems.
- Construct projects and products specific to the Engineering and Architecture sector requirements and expectations. *AS 10.3*
  - Demonstrate knowledge of the single-chip microcomputer, including its programming model, instruction set, internal architecture, and how it interfaces with outside hardware.
  - Complete a research project: Robots in the News

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## II. INTRODUCTION TO ROBOTICS ENGINEERING (Continued)

### P. Communication and Teamwork

1. Brainstorming and Feedback
2. Communicating Ideas and Data
3. Working in Teams

- Interpret verbal and nonverbal communications and respond appropriately. *AS 2.3*
- Communicate information and ideas effectively to multiple audiences using a variety of media and formats. *AS 2.5*
  - Understand and demonstrate communication skills necessary in the field of engineering.
  - Make an oral presentation.
  - Express data in tables, graphs, charts, and other visual formats.
- Identify and ask significant questions that clarify various points of view to solve problems. *AS 5.1*
- Interpret information and draw conclusions, based on the best analysis, to make informed decisions. *AS 5.4*
- Determine what information and principles are relevant to a problem and its analysis. *PS B6.2*
- Participate in interactive teamwork to solve real Engineering and Architecture sector issues and problems. *AS 9.7*
  - Employ an individual and team approach while solving engineering problems.
  - Contribute to the successful completion of a team project.
### III. ADVANCED ROBOTICS ENGINEERING

#### A. Advanced Application of Robotics Technology
1. NASA Exploration

- Research past, present, and projected technological advances as they impact a particular pathway. *AS 4.5*
  - Understand present and future applications for Robotics Technology has a role in space science and medical advancements.
  - Research several applications and report on one specific application.
  - Describe robotics technology applications including those for scientific and medical purposes.
  - Propose a new application for robot technology within or outside of the above categories.

#### B. Units of Measure Review
1. Units
2. Unit Conversion
3. Fundamental Physical Parameters

- Understand industrial engineering processes, including use of tools and equipment, methods of measurement, and quality assurance. *PS B7.0*
  - Understand the use of electronic test equipment and units of measure.
  - Select and apply appropriate equipment or tools.
  - Analyze and apply observed measurements.

#### C. Mathematics for Robotics
1. Math Models of Gear Systems, Belt, and Pulley Systems
2. Ohm’s Law
3. Resistance and Capacitance
4. Electric Power Problems

- Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate. *PS 5.2*
  - Understand the mathematical processes and applications that lead to solutions of electronic problems.
  - Calculate various gear ratios for different mechanical applications.
  - Solve Direct-Current (DC) circuit analysis problems using...
### III. ADVANCED ROBOTICS ENGINEERING
(Continued)

#### D. Advanced Circuits and Measurement Tools

1. **Lab Equipment:**
   - Oscilloscope, Multimeters, Power Supplies, Measuring Tape

2. **Advanced Electronic Learning Lab**

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| **Ohm’s Law.** | - Calculate fundamental Alternating Current (AC) parameters.  
- Manipulate scientific notation in problem solutions.  
- Derive algebraic equations to determine unknown values in circuits.  
- Utilize a scientific calculator as a tool for problem solving.  
- Solve multi-step problems including word problems using linear equations in one variable.  |

- Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment. *AS 5.3*
  - Understand at an advanced level the relationships between voltage, current, resistance and power as pertaining to direct-current circuits.

- Understand industrial engineering processes, including use of tools and equipment, methods of measurement, and quality assurance. *PS B7.0*
  - Measure current, voltage, and resistance in various segments of parallel and series circuits.
  - Measure digital circuits with oscilloscope.
  - Collect temporal data with the PC/multimeter.
  - Conduct laboratory experiments, which include detailed problem, theory, results and discussion sections, including the use of lab equipment for measurement.
### III. ADVANCED ROBOTICS ENGINEERING (Continued)

#### E. Advanced Electronic Assembly
1. Schematic Diagrams
2. Assembly Tools
3. Electronic Assembly Skills
4. Electronic Learning Lab
5. PLCs (Programmable Logic Controller)

- Interpret and explain terminology and practices specific to the Engineering and Architecture sector. *AS 10.1*
  - Understand the procedures and processes related to electronic assembly.
- Construct projects and products specific to the Engineering and Architecture sector requirements and expectations. *AS 10.3*
  - Construct an electronic device following a schematic diagram as a sole reference utilizing the Electronics Learning Lab utilizing integrated circuits, capacitors, resistors, switches, LEDs and wire.
  - Interface a PLC with the outside world and program it to demonstrate the student’s knowledge and understanding of the device’s capabilities.

#### F. Manufacturing Methods
1. Manufacturing Methods
2. Sequence of Operations
3. Quality Control

- Describe the major manufacturing processes. *PS B7.2*
  - Understand the advantages and disadvantages of various manufacturing methods.
  - Investigate and evaluate appropriate manufacturing methods.
- Know the structure and processes of a quality assurance cycle. *PS B7.1*
  - Explain quality control in manufacturing.
- Construct projects and products specific to the Engineering and Architecture sector requirements and expectations. *AS 10.3*
  - Establish an effective sequence of operations for a given design problem.
  - Use appropriate manufacturing processes to produce an actual product.
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<td>III. ADVANCED ROBOTICS ENGINEERING (Continued)</td>
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<tr>
<td>G. Machinery and Equipment</td>
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</tbody>
</table>
| 1. Computerized Controllers | • Understand fundamental control system design and develop systems that complete programmed tasks. *PS B8.0*  
  o Understand the machinery and equipment used to manufacture a given product.  
  o Demonstrate the application of computerized controllers to operate machinery, equipment and processes.  
  o Demonstrate the use and application of hydraulic, pneumatic, and mechanical controls in a robot system. |
| 2. Hydraulic, Pneumatic, and Mechanical Controls | |
| H. Measurement in Manufacturing | • Calibrate precision measurement tools and instruments to measure objects. *PS B7.6*  
  o Understand the concepts of precision, accuracy, and appropriate units of measurement and their application in manufacturing processes.  
  o Demonstrate the ability to select and utilize the proper measurement tool based on the product and required tolerance.  
  o Verify proper calibration and take appropriate actions to correct the measuring tools.  
  o Perform unit conversions between systems such as metric and traditional English based measurements  
  • Apply appropriate geometric dimensioning and tolerancing (GD&T) practices. *PS B7.5* |
| 1. Measurement Tools | |
| 2. Calibration | |
| 3. Metric System | |

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### III. ADVANCED ROBOTICS ENGINEERING (Continued)

#### I. Environment and Manufacturing

1. Regulatory Agencies and Manufacturing
2. Effect of the Manufacturing Process and on Environment
3. Design Process
4. Design Failures

- Interpret policies, procedures, and regulations for the workplace environment, including employer and employee responsibilities. *AS 6.2*
- Identify local, district, state, and federal regulatory agencies, entities, laws, and regulations related to the Engineering and Architecture industry sector. *AS 8.2*
  - Describe roles and responsibilities of state and federal regulatory agencies that affect manufacturing operations.
- Demonstrate ethical and legal practices consistent with Engineering and Architecture sector workplace standards. *AS 8.3*
  - Understand the impact and importance of environmental issues related to manufacturing processes and organizations.
  - Develop an appreciation and understanding of the effect of product and process design on the environment.
  - Describe how decisions made at the product or process design stage can affect the environment during the life of a product or process "from the cradle to the grave."
  - Examine design failures and how they have affected the environment.

#### J. Material Selection

1. Product Requirements
2. Characteristics of Materials
3. Balancing Quality Verses Time

- Understand the process of product development. *PS B9.1*
  - Understand the uses and the requirements that material selection place on the manufacturing method and processes.
  - Demonstrate the ability to select an appropriate process for a given material.
  - Select an appropriate material based upon product requirements.
### III. ADVANCED ROBOTICS ENGINEERING (Continued)

#### K. Manufacturing Costs
1. Cost Effectiveness
2. Cost Expectations as Drivers of Process
3. Cost Expectations as Drivers of Material Selection

#### L. Planning, Scheduling, and Time Management
1. Planning
2. Scheduling
3. Multiple Demand on Time
4. Teamwork
5. Modification of Schedule

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<td>o Balance quality requirements verses timely product completion in the manufacturing process.</td>
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<tr>
<td>▪ Demonstrate knowledge and practice of responsible financial management. <em>AS 7.6</em></td>
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<tr>
<td>o Evaluate the cost effectiveness of the material selections for a given product.</td>
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<tr>
<td>o Understand the actual cost in time, material, and tooling expenses related to the product manufacturing cycle.</td>
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<tr>
<td>o Determine the appropriate processes or methods to meet cost expectations.</td>
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<tr>
<td>o Understand the relationship between the cost and material selection.</td>
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<tr>
<td>▪ Practice time management and efficiency to fulfill responsibilities. <em>AS 7.4</em></td>
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<tr>
<td>o Understand the different aspects of manufacturing management that includes personal time management, team participation/dynamics, and scheduling of priorities.</td>
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<tr>
<td>o Create a planning sequence for the production of a product.</td>
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<td>o Develop a schedule from start to completion of the product.</td>
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<td>o Demonstrate the ability to modify or adapt individual’s schedule and plan as required.</td>
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<tr>
<td>o Balance multiple demands for time (i.e., several products/processes/classes).</td>
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<tr>
<td>▪ Participate in interactive teamwork to solve real Engineering and Architecture sector issues and problems. <em>AS 9.7</em></td>
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### III. ADVANCED ROBOTICS ENGINEERING
(Continued)

#### M. Communications
1. Brainstorming and Feedback
2. Communicating Ideas and Data
3. Technical Drawings
4. Computer Interfacing
5. Microcontroller Interfacing
6. PowerPoint Presentations
7. E-mail

- Acquire and accurately use Engineering and Architecture sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats. *AS 2.0*
  - Understand effective communication strategies for conveying electronic information in an industrial environment.
  - Demonstrate the ability to read and interpret technical drawings accurately.
  - Make an oral presentation.
  - Express data in tables, graphs, charts, and other visual formats.

- Use existing and emerging technology to investigate, research, and produce products and services, including new information, as required in the Engineering and Architecture sector workplace environment. *AS 4.0*
  - Demonstrate the ability to interface technical information between computers, machine controllers, and machinery.
  - Demonstrate the ability to convey information electronically.

- Determine what information and principles are relevant to a problem and its analysis. *PS B6.2*

- Participate in interactive teamwork to solve real Engineering and Architecture sector issues and problems. *AS 9.7*
  - Contribute to the successful completion of a team project.

#### N. Advanced Design Process/Problem Solving
1. Steps of the Engineering Design Process

- Employ the design process to solve analysis and design problems. *PS B6.0*
  - Understand at an advanced level the design process and how to solve analysis and design problems.
## III. ADVANCED ROBOTICS ENGINEERING (Continued)

2. Mission Statements
3. Requirements and Constraints
4. System Engineering Methods
5. System Design Drivers
6. Product Design Specifications
7. System Requirements
8. Literature Search
9. Performance, Cost, and Reliability
10. Selection of Subsystems
11. CAD/CAM
12. Design Portfolios: Specifications, Systems Descriptions, Results and Analyses, and Drawings
13. Reverse Engineering
14. Design Project Documentation
15. Multiple Solutions Legal Concepts

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<td>o Determine what information and principles are relevant to a problem and its analysis. <em>PS B6.2</em></td>
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<tr>
<td>o Understand the steps in the design process. <em>PS B6.1</em></td>
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<td>o Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution. <em>PS B6.3</em></td>
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<td>o Demonstrate the process of developing multiple details, within design constraints, into a single solution. <em>PS B6.5</em></td>
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<td>o Translate word problems into mathematical statements when appropriate. <em>PS B6.4</em></td>
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<tr>
<td>• Communicate and interpret information clearly in industry-standard visual and written formats. <em>PS B1.0</em></td>
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<tr>
<td>o Select and finalize the solutions and completing a working drawing (i.e. Mechanical, CAD, freehand drawings).</td>
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<tr>
<td>o Prepare a thorough technical documentation of a conceptual design.</td>
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<td>o Develop supporting text, data, and diagrams for a design presentation.</td>
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<td>o Prepare a three-view drawing of the design showing the subsystem layout.</td>
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<td>o Participate in the delivery of the final design presentation to fellow students and invited guests.</td>
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<tr>
<td>• Construct a prototype from plans and test it. <em>PS B6.6</em></td>
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<tr>
<td>o Use appropriate materials, tools, and processes to fabricate a model (form) of the solution.</td>
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<td>o Test model as appropriate.</td>
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<tr>
<td>o Disassemble an existing design to understand construction details.</td>
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<tr>
<td>o Develop a working model (function) and/or prototype.</td>
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### III. ADVANCED ROBOTICS ENGINEERING (Continued)

**O. Advanced Engineering Systems**

2. Force, Work, Rate, Power, Energy, and Resistance
3. Analog a Digital System
4. Safety Devices
5. AC/DC Systems
6. Hydraulic & Pneumatic

- Collaborate with industry experts (community and corporate mentors) for specific technical knowledge and skills. *AS 10.4*
- Adhere to copyright and intellectual property laws and regulations, and use and appropriately cite proprietary information. *AS 8.7*
- Comply with the rules, regulations, and expectations of all aspects of the Engineering and Architecture sector. *AS 10.2*
  - Understand the concepts relating to copyright, trademark, and patent laws.
- Evaluate and redesign a prototype on the basis of collected test data. *PS B6.7*
  - Develop alternative plans for redesigning devices and systems.
  - Consider design specifications and constraints by balancing needs, the availability of resources, and environmental impacts.
  - Develop the details of multiple solutions.

- Understand (at an advanced level) and apply how the Principles of force, work, rate, power, energy, and resistance related to mechanical, electrical, fluid, and thermal engineering systems. *PS B5.0*
  - Demonstrate the effect of resistance.
  - Solve problems using appropriate units in engineering systems.
  - Apply Ohm’s Law.
  - Give a physical description of inductors and capacitors and describe how they function.
  - Use appropriate electrical units to solve problems.
  - Identify series, parallel, and combination circuits.
  - Draw a circuit diagram and layout the circuit.
  - Identify the difference between analog and digital signals.
### III. ADVANCED ROBOTICS ENGINEERING (Continued)

#### P. Systems Thinking
1. Input, Process, Output, Feedback
2. Technological Systems

- Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment. *AS 5.3*
  - Understand and apply the universal technology systems model (input, process, output, and feedback) in a robotics-manufacturing environment.
  - Explain the function(s) of each of the following elements of technological systems; inputs, processes, outputs, and feedback.
  - Produce and analyze various technological systems and identify the ways in which they are controlled to produce a desired outcome.
  - Demonstrate how feedback can improve the way a system works.
  - Illustrate how systems are planned, designed, constructed, and applied to perform a task.
  - Identify a systems problem and generating a solution.

#### Q. Advanced Robot Systems
1. Power
2. Controller
3. Actuators
4. Drive
5. Sensors
6. Transducers

- Understand fundamental control system design and develop systems that complete preprogrammed tasks. *PS B8.0*
  - Identify and understand, at an advanced level, the function of, manipulate, and assemble commonly used electromechanical components into a comprehensive robot system.
  - Program the BOE-BOT at an advanced level.
  - Assemble and program the Toddler Robot.
  - Examine the mathematical similarities of electronics,

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<td>1. Input, Process, Output, Feedback</td>
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<td>4. Drive</td>
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<td>5. Sensors</td>
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<td>6. Transducers</td>
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<tr>
<td>INSTRUCTIONAL CONTENT</td>
<td>STUDENT OUTCOMES</td>
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<tr>
<td>III. ADVANCED ROBOTICS INSTRUCTIONAL ENGINEERING</td>
<td>student outcomes</td>
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<td>(Continued)</td>
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<tr>
<td>7. Motors</td>
<td>hydraulics, and mechanics.</td>
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<tr>
<td>8. Relays</td>
<td>o Build an electromechanical system—Robot (Major group</td>
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<tr>
<td>10. Cylinders</td>
<td>o Determine current, voltage, and logic of a given system.</td>
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<td>11. Movement Systems</td>
<td>o Write a block diagram for a given system detailing the control</td>
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<tr>
<td>12. Electromechanical</td>
<td>logic of the circuit and its effect on the mechanical portion of</td>
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<tr>
<td>systems</td>
<td>the system.</td>
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<tr>
<td>13. AC/DC Electrical Systems</td>
<td>o Give a detailed presentation on an electromechanical system</td>
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<tr>
<td>14. Hydraulic/Pneumatic</td>
<td>using presentation tools available in industry such as Microsoft</td>
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<td>Power Systems</td>
<td>Power Point.</td>
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<td>15. Work Envelope</td>
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<td>16. Maintenance of Robotics</td>
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<td>Systems</td>
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<td>17. Robotics Sensing Systems</td>
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<td>18. Tactile, Proximity, and</td>
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<td>Photoelectric Sensors</td>
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<td>19. Limit Switches</td>
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<td>20. End of Arm Tooling</td>
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<td>21. Energy Conversion</td>
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<td>22. Energy Storage</td>
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<td>23. BOE-BOT (Parallax)</td>
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<td>24. Toddler (Parallax)</td>
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<td>III. ADVANCED ROBOTICS ENGINEERING (Continued)</td>
<td>• Understand (at an advanced level) fundamental control system design and develop systems that complete preprogrammed tasks. &lt;i&gt;PS B8.0&lt;/i&gt;</td>
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<td>R. Advanced Control Systems</td>
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<td>1. Semiconductor Devices</td>
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<td>2. Software</td>
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<td>3. Programming</td>
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<td>4. BOE-BOT (Parallax)</td>
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<td>5. Toddler (Parallax)</td>
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<td>6. Javelin chip (Parallax)</td>
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<td>7. Input/output</td>
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<td>8. Memory</td>
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<td>9. Digital electronics</td>
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<td>10. Programmable Logic Controllers</td>
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<td>11. Monitoring Devices</td>
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<td>12. Microprocessors</td>
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<td>13. Control Software</td>
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<td>14. Robot Interfacing</td>
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<td>15. Vision Systems</td>
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<td>16. Artificial Intelligence</td>
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<td>17. Expert Systems</td>
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<td>18. The Future of Robotics</td>
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<td>S. Technology and Society</td>
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<td>1. Impact of Technological Advances on Society</td>
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<td>• Research past, present, and projected technological advances as they impact a particular pathway. &lt;i&gt;AS 4.5&lt;/i&gt;</td>
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<td>o Project and forecast the development of future technological needs and uses.</td>
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### III. ADVANCED ROBOTICS ENGINEERING  
(Continued)

2. Impact of Technological Advances on the Environment
3. Impact of Technological Advances on Culture
4. Interface of Technology and Ethics
5. Controlling Technology
6. The Future of Technology

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<th>INSTRUCTIONAL CONTENT</th>
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| **• Explore issues of global significance and document the impact on the Engineering and Architecture sector. AS 7.8**  
  o Understand the impact that technological advances and society have on society, environment, and culture.  
  o Describe why technological advances may have both desirable and undesirable impacts on society.  
  o Interpret the impacts of technological advances on the environment.** |
| **• Demonstrate ethical and legal practices consistent with Engineering and Architecture sector workplace standards. AS 8.3.**  
  o Explain the interface between technological advances and human ethics.  
  o Describe how humans are faced with moral and ethical issues because technology is enabling very significant modifications of the natural world.  
  o Discuss societies' ability/inability to control the technologies they have created.** |
| **• Understand that the modern world is an international community and requires an expanded global view. AS 8.5**  
  o Discuss the impacts of technological advances and cultural norms/customs on each other.  
  o Analyze how technological advances affect local, nationals and global economies.** |

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Engineering and Architecture

Sector Description

This sector is designed to provide a foundation in engineering, architecture, and design for students in California. Students are engaged in an instructional program that integrates academic and technical preparation and focuses on career awareness, career exploration, and career preparation in four pathways that emphasize real-world, occupationally relevant experiences of significant scope and depth: Architectural Design; Engineering Technology; Engineering Design; and Environmental Engineering. To prepare students for continued training, advanced educational opportunities, and direct entry to a career, the Engineering and Architecture programs offer the following components: classroom, laboratory, and hands-on contextual learning; project- and work-based instruction; and leadership and interpersonal skills development.
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 Engineering and Architecture academic alignment matrix for identification of standards.

2.0 Communications
Acquire and accurately use Engineering and Architecture 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.

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 Engineering and Architecture 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 Web-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 projects to create alternative solutions to answer a question or solve a problem unique to the Engineering and Architecture 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.

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 Engineering and Architecture 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).

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 Engineering and Architecture 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 Engineering and Architecture 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 Engineering and Architecture industry sector.

8.3 Demonstrate ethical and legal practices consistent with Engineering and Architecture 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 Engineering and Architecture sector laws and practices.

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 as practiced in the 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 Engineering and Architecture sector issues and problems.

10.0 Technical Knowledge and Skills

Apply essential technical knowledge and skills common to all pathways in the Engineering and Architecture 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 Engineering and Architecture sector.

10.2 Comply with the rules, regulations, and expectations of all aspects of the Engineering and Architecture sector.
10.3 Construct projects and products specific to the Engineering and Architecture sector requirements and expectations.

10.4 Collaborate with industry experts for specific technical knowledge and skills.

11.0 Demonstration and Application

Demonstrate and apply the knowledge and skills contained in the Engineering and Architecture anchor standards, pathway standards, and performance indicators in classroom, laboratory and workplace settings, and through the SkillsUSA career technical student organization.

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 Engineering and Architecture 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 Engineering and Architecture 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.
A. Architectural Design Pathway

The Architectural Design pathway provides learning opportunities for students interested in preparing for careers in such areas as architecture, industrial design, and civil engineering.

Sample occupations associated with this pathway:

- Drafter
- Architect
- Structural Designer
- Building Department Plan Examiner
- City Planner

A1.0 Understand how history shaped architecture and know significant events in the history of architectural design.

A1.1 Know significant historical architectural projects and their effects on society.

A1.2 Understand the development of architectural systems in relation to aesthetics, efficiency, and safety.

A2.0 Compare the theoretical, practical, and contextual issues that influence design.

A2.1 Describe the influence of community context and zoning requirements on architectural design.

A2.2 Understand the ways in which sociocultural conditions and issues influence architectural design.

A2.3 Compare the theoretical and practical effects of human and physical factors on the development of architectural designs.

A2.4 Analyze project design and compile a cost analysis.

A3.0 Understand the sketching processes used in concept development.

A3.1 Apply sketching techniques to a variety of architectural models.

A3.2 Produce proportional two- and three-dimensional sketches and designs.

A3.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.

A4.0 Understand the use of computer-aided drafting (CAD) in developing architectural designs.

A4.1 Develop a preliminary architectural proposal using CAD software.

A4.2 Analyze viability of a project as the design is developed using Building Information Modeling (BIM).
A5.0  Compare the relationship between architecture and the external environment.
   A5.1  Understand the significance of sustainable building design practices that incorporate beneficial energy and environmental design policies.
   A5.2  Develop a site analysis that considers passive energy techniques, sustainability issues, and landscaping.
   A5.3  Create a building design that incorporates passive and/or active energy-efficient technologies.

A6.0  Understand methods used to analyze simple structures.
   A6.1  Understand load transfer mechanisms.
   A6.2  Understand stress-strain relationships of building structures.
   A6.3  Interpret structural design considerations, including load-bearing relationships of shear walls, columns, and beams.
   A6.4  Design a simple structure by using structural analysis principles.

A7.0  Understand the properties of structural materials.
   A7.1  Understand the integration of architectural factors, such as soil mechanics, foundation design, engineering materials, and structure design.
   A7.2  Develop a stress analysis chart of typical structural components.
   A7.3  Evaluate available building materials (e.g., steel, concrete, and wood) by considering their properties and their effect on building form.
   A7.4  Develop a preliminary building plan using the appropriate materials.

A8.0  Systematically complete an architectural project.
   A8.1  Describe the various components of structures, including lighting; heating, ventilating, and air-conditioning (HVAC); mechanical; electrical; plumbing; communication; security; and vertical transportation systems.
   A8.2  Develop a preliminary proposal for presentation of an architectural design.
   A8.3  Read and interpret architectural and construction plans, drawings, diagrams, and specifications.
   A8.4  Develop a complete set of architectural plans and drawings.
   A8.5  Estimate the materials needed for a project by reading an architectural drawing.
   A8.6  Plan a project using site and building restrictions imposed by various entities (e.g., Planning, Zoning, Building, and Home Owners Association [HOA]).
   A8.7  Plan the sequence of events leading to an architectural project.

A9.0  Using various methods create both written and digital portfolios to represent architectural renderings.
   A9.1  Develop a binder or digital portfolio representative of completed work for presentation.
   A9.2  Prepare an effective oral presentation of the portfolio content.
B. Engineering Technology Pathway

The Engineering Technology pathway provides learning opportunities for students interested in preparing for careers in the design, production, or maintenance of mechanical, electrical, electronics, or electromechanical products and systems.

Sample occupations associated with this pathway:
- Surveyor
- Research and Development Analyst
- Engineering Technologist
- Field Engineer
- Operations Engineer

B1.0 Communicate and interpret information clearly in industry-standard visual and written formats.
  B1.1 Explain the classification and use of various components, symbols, abbreviations, and media common to technical drawings.
  B1.2 Describe the current industry standards for illustration and layout.
  B1.3 Draw flat layouts of a variety of objects by using the correct drafting tools, techniques, and media.
  B1.4 Organize and complete an assembly drawing using information collected from detailed drawings.
  B1.5 Create reports and data sheets for writing specifications.

B2.0 Demonstrate the sketching process used in concept development.
  B2.1 Understand the process of producing proportional two- and three-dimensional sketches and designs.
  B2.2 Apply sketching techniques to a variety of architectural and engineering models.
  B2.3 Present conceptual ideas, analysis, and design concepts using freehand graphic communication techniques.

B3.0 Identify the fundamentals of the theory, measurement, control, and applications of electrical energy, including alternating and direct currents.
  B3.1 Understand the characteristics of alternating current (AC) and how it is generated; the characteristics of the sine wave; and of AC, tuned, and resonant circuits; and the nature of the frequency spectrum.
  B3.2 Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits.
  B3.3 Calculate, construct, measure, and interpret both AC and DC circuits.
  B3.4 Understand how electrical control and protection devices are used in electrical systems.
B3.5 Calculate loads, currents, and circuit-operating parameters.
B3.6 Classify and use various electrical components, symbols, abbreviations, media, and standards of electrical drawings.
B3.7 Analyze, repair, or measure electrical and electronic systems, circuits, or components using appropriate electronic instruments.
B3.8 Predict the effects of circuit conditions on the basis of measurements and calculations of voltage, current, resistance, and power.

B4.0 Understand the concepts of physics that are fundamental to engineering technology.
B4.1 Describe Newton's laws and how they affect and define the movement of objects.
B4.2 Explain how the laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.
B4.3 Compare the effects and applications of heat transfer and thermal dynamic processes.
B4.4 Explore the fundamentals and properties of waveforms and how waveforms may be used to carry energy.
B4.5 Analyze how electric and magnetic phenomena are related and know common practical applications.

B5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.
B5.1 Differentiate between scalars and vectors.
B5.2 Solve problems by using the concept of vectoring to predict resultants.
B5.3 Compare and explore the six simple machines and their applications.
B5.4 Evaluate how energy is transferred and predict the effects of resistance in mechanical, electrical, fluid, and thermal systems.
B5.5 Formulate and solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems.

B6.0 Employ the design process to solve analysis and design problems.
B6.1 Understand the steps in the design process.
B6.2 Determine what information and principles are relevant to a problem and its analysis.
B6.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
B6.4 Translate word problems into mathematical statements when appropriate.
B6.5 Demonstrate the process of developing multiple details, within design constraints, into a single solution.
B6.6 Construct a prototype from plans and test it.
B6.7 Evaluate and redesign a prototype on the basis of collected test data.
B7.0 Understand industrial engineering processes, including the use of tools and equipment, methods of measurement, and quality assurance.

B7.1 Know the structure and processes of a quality assurance cycle.

B7.2 Describe the major manufacturing processes.

B7.3 Use tools, fasteners, and joining systems employed in selected engineering processes.

B7.4 Estimate and measure the size of objects in both Standard International and United States units.

B7.5 Apply appropriate geometric dimensioning and tolerancing (GD&T) practices.

B7.6 Calibrate precision measurement tools and instruments to measure objects.

B8.0 Understand fundamental control system design and develop systems that complete preprogrammed tasks.

B8.1 Identify the elements and processes necessary to develop a controlled system that performs a task.

B8.2 Demonstrate the use of sensors for data collection and process correction in controlled systems.

B8.3 Perform tests, collect data, analyze relationships, and display data in a simulated or modeled system using appropriate tools and technology.

B8.4 Program a computing device to control systems or process.

B8.5 Use motors, solenoids, and similar devices as output mechanisms in controlled systems.

B8.6 Assemble input, processing, and output devices to create controlled systems capable of accurately completing a preprogrammed task.

B9.0 Understand the fundamentals of systems and market influences on products as they are developed and released to production.

B9.1 Understand the process of product development.

B9.2 Understand decision matrices and the use of graphic tools in illustrating the development of a product and the processes involved.

B10.0 Design and construct a culminating project effectively using engineering technology.

B10.1 Use methods and techniques for employing all engineering technology equipment appropriately.

B10.2 Apply conventional engineering technology processes and procedures accurately, appropriately, and safely.

B10.3 Apply the concepts of engineering technology to the tools, equipment, projects, and procedures of the Engineering Technology Pathway.

B11.0 Understand the methods of creating both written and digital portfolios.

B11.1 Develop a binder or digital portfolio representative of student work for presentation.

B11.2 Give an effective oral presentation of a portfolio.
C. Engineering Design Pathway

The Engineering Design pathway provides learning opportunities for students interested in preparing for careers in the design and production of visual communications.

Sample occupations associated with this pathway:
- Mechanical/Electrical Drafter
- Design Engineer
- Manufacturing Design Engineer
- Project Architect

C1.0 Understand historical and current events related to engineering design and their effects on society.
  C1.1 Know historical and current events that have relevance to engineering design.
  C1.2 Interpret the development of graphic language in relation to engineering design.

C2.0 Understand the effective use of engineering design equipment.
  C2.1 Employ engineering design equipment using the appropriate methods and techniques.
  C2.2 Apply conventional engineering design equipment procedures accurately, appropriately, and safely.
  C2.3 Apply the concepts of engineering design to the tools, equipment, projects, and procedures of the Engineering Design Pathway.

C3.0 Understand the sketching process used in concept development.
  C3.1 Apply sketching techniques to a variety of architectural models.
  C3.2 Produce proportional two- and three-dimensional sketches and designs.
  C3.3 Present conceptual ideas, analysis, and design concepts using freehand, graphic, communication techniques.

C4.0 Understand measurement systems as they apply to engineering design.
  C4.1 Know how the various measurement systems are used in engineering drawings.
  C4.2 Understand the degree of accuracy necessary for engineering design.

C5.0 Use proper projection techniques to develop orthographic drawings.
  C5.1 Understand the concepts and procedures necessary for producing drawings.
  C5.2 Develop multiview drawings using the orthographic projection process.
  C5.3 Understand the various techniques for viewing objects.
  C5.4 Use the concepts of geometric construction in the development of design drawings.
  C5.5 Apply pictorial drawings derived from orthographic multiview drawings and sketches.
C6.0 Understand the applications and functions of sectional views.
   C6.1 Understand the function of sectional views.
   C6.2 Clarify hidden features of an object using a sectional view and appropriate cutting planes.

C7.0 Understand the applications and functions of auxiliary views.
   C7.1 Understand the function of auxiliary views.
   C7.2 Use auxiliary views to clarify the true shape and size of an object.

C8.0 Understand and apply proper dimensioning standards to drawings.
   C8.1 Know a variety of drafting applications and understand the proper dimensioning standards for each.
   C8.2 Apply dimension to various objects and features.

C9.0 Understand the tolerance relationships between mating parts.
   C9.1 Understand what constitutes mating parts in engineering design.
   C9.2 Interpret geometric tolerancing symbols in a drawing.
   C9.3 Use tolerancing in an engineering drawing.

C10.0 Understand the methods of applying text to a drawing.
   C10.1 Describe the processes of lettering and/or text editing.
   C10.2 Implement standard methods of title block creation and use.
   C10.3 Develop drawings using notes and specifications.
   C10.4 Plan, prepare, and interpret drawings and models through traditional drafting or computer-aided design (CAD) techniques.

C11.0 Understand the methods of creating both written and digital portfolios.
   C11.1 Develop a binder or digital portfolio representative of completed work for presentation.
   C11.2 Give an effective oral presentation of a portfolio.
D. Environmental Engineering Pathway

The Environmental Engineering pathway includes design and development processes, equipment, and systems that are used to create, monitor, prevent, or correct environmental events and conditions.

Sample occupations associated with this pathway:
- Environmental Safety Technician
- Environmental Specialist
- Environmental Analyst
- Environmental Scientist
- Air Pollution Control Engineer

D1.0 Communicate and interpret information clearly in industry-standard visual and written formats.
  D1.1 Know the current industry standards for illustration and layout.
  D1.2 Understand the classification and use of various electronic components, symbols, abbreviations, and media common to electronic drawings.
  D1.3 Organize and complete site plans.

D2.0 Understand the design process and how to solve analysis and design problems.
  D2.1 Understand the steps in the design process.
  D2.2 Determine what information and principles are relevant to a problem and its analysis.
  D2.3 Choose between alternate solutions in solving a problem and be able to justify choices in determining a solution.
  D2.4 Understand the process of developing multiple details into a single solution.
  D2.5 Translate word problems into mathematical statements when appropriate.
  D2.6 Build a prototype from plans and test it.
  D2.7 Evaluate and redesign a prototype on the basis of collected test data.

D3.0 Understand the fundamentals of earth science as they relate to environmental engineering.
  D3.1 Know the fundamental stages of geochemical cycles.
  D3.2 Understand the effects of pollution on hydrological features.
  D3.3 Classify the three major groups of rocks, according to their origin, on the basis of texture and mineral composition.
  D3.4 Analyze the importance and use of soil and evaluate how soil may be preserved and conserved.
  D3.5 Assess and evaluate geological hazards.
D3.6 Interpret and evaluate topographical maps and images.
D3.7 Locate and evaluate soil or geological conditions or features using global positioning systems equipment and related technology.
D3.8 Analyze soil erosion and identify the causes.

D4.0 Understand the effects of the weather, the hydrosphere, and the atmosphere on the environment.
D4.1 Know the common causes of atmospheric contamination.
D4.2 Understand the effects of weather fronts on regional air pollution.
D4.3 Understand the relationship between the health of the marine environment and climate control.
D4.4 Understand the effects of human activity on the atmospheric environment.
D4.5 Analyze and predict conditions of meteorological events.
D4.6 Analyze the mechanisms for air mass movement.
D4.7 Analyze atmospheric pressure and weather systems.

D5.0 Understand how the principles of force, work, rate, power, energy, and resistance relate to mechanical, electrical, fluid, and thermal engineering systems.
D5.1 Know the six simple machines and their applications.
D5.2 Know how energy is transferred and the effects of resistance in mechanical, electrical, fluid, and thermal systems.
D5.3 Understand scalars and vectors.
D5.4 Solve problems by using the concept of vectoring to predict the resultant forces.
D5.5 Solve problems by using the appropriate units applied in mechanical, electrical, fluid, and thermal engineering systems.

D6.0 Evaluate regional interactive systems and elements that create harmful environmental effects.
D6.1 Describe the sources of, and impacts attributable to, pollution and contamination.
D6.2 Recognize the actions that cause resource depletion.
D6.3 Define the causes of erosion and soil depletion.
D6.4 Describe the attributes and proliferation of hardscape.
D6.5 Identify the sources of, and impacts attributable to, habitat alteration.

D7.0 Understand the concepts of physics that are fundamental to engineering technology.
D7.1 Understand Newton's laws and how they affect and define the movement of objects.
D7.2 Understand how the laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.
D7.3 Understand how electric and magnetic phenomena are related and know common practical applications.

D7.4 Analyze the fundamentals and properties of waveforms and how waveforms may be used to carry energy.

D8.0 Understand the effective use of environmental and natural science equipment.

D8.1 Use appropriate methods and techniques for employing environmental and natural science equipment.

D8.2 Apply conventional environmental and natural science processes and procedures accurately, appropriately, and safely.

D8.3 Apply the concepts of environmental and natural science to the tools, equipment, projects, and procedures of the Environmental Engineering Pathway.

D9.0 Identify the role and impact of waste management systems, and their operations, on the environment.

D9.1 Understand the role of waste and storm water management systems, their operation, and their impact on the environment.

D9.2 Explore the causes and effects of pollution linked to wastewater treatment facilities.

D9.3 Identify wastewater treatment processes that lessen environmental impacts and improve water reuse.

D9.4 Explain the types and sources of hazardous waste and associated safety practices and legal requirements for handling and disposing of such waste.

D9.5 Design solid waste disposal processes that lessen environmental impacts and improve recycling.

D10.0 Understand the field of land use management and its potential for environmental impact.

D10.1 Describe the need for and role of habitat preservation.

D10.2 Describe the composition, role, and function of ecosystems, including trends affecting viability.

D10.3 Explain the laws and regulations pertaining to ecosystem preservation and use.

D10.4 Demonstrate the need for, and methods of, land use planning.

D10.5 Identify the aspects of land use planning and describe current trends.

D10.6 Summarize the relationship between land use planning and energy use and distribution.

D10.7 Explain the laws and regulations pertaining to land use planning.

D10.8 Develop strategies to maximize the effectiveness of land use planning.

D11.0 Research the role of air quality management and systems, their operations, and their impact on the environment.

D11.1 Understand the elements that create outdoor air quality.
D11.2 Summarize the causes of air pollutants and their chemical composition.
D11.3 Research air pollutants and their threat to human health.
D11.4 Understand U.S. and California laws and regulations related to air pollution control programs and health effects of air pollution.
D11.5 Describe the basic U.S. Environmental Protection Agency (EPA) and California Air Resources Board (ARB) roles and regulations.

D12.0 Implement processes to support energy efficiency.
  D12.1 Understand the relationship between power and energy efficiency.
  D12.2 Outline how domestic and industrial appliances and systems affect the environment, such as water units and heating and cooling systems.
  D12.3 Compare costs of alternate/renewable energy sources, systems, and appliances and traditional energy sources, systems, and appliances.
  D12.4 Conduct an energy audit.

D13.0 Research drinking-water sources, systems, treatment, and conservation.
  D13.1 Understand water reuse: issues, strategies, technologies, and applications.
  D13.2 Analyze strategies for improving energy efficiencies in water collection and distribution.
  D13.3 Describe the role of environmental engineering and green energy in water systems.
  D13.4 Understand the functions and operations of water storage, reservoirs, aqueducts, and dams.
  D13.5 Identify and explain the applicable codes and regulations.

D14.0 Evaluate the impact and flow management of storm water, rivers, and groundwater.
  D14.1 Understand the designs and tools used in water flow management.
  D14.2 Describe watershed modeling.
  D14.3 Understand the principles and applications of drainage engineering.
  D14.4 Use the Hydrologic Engineering Centers River Analysis System (HEC-RAS).
  D14.5 Analyze and interpret contaminated harbor and river sediment.
  D14.6 Describe the concerns and strategies for catastrophic storm water events and management.
## Academic Alignment Matrix

### Engineering and Architecture

<table>
<thead>
<tr>
<th>ENGLISH LANGUAGE ARTS</th>
<th>PATHWAYS</th>
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<tbody>
<tr>
<td></td>
<td>A. Architectural Design</td>
</tr>
<tr>
<td>Language Standards – LS (Standard Area, Grade Level, Standard #)</td>
<td></td>
</tr>
<tr>
<td>11-12.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.</td>
<td>A9.0</td>
</tr>
<tr>
<td>11-12.2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.</td>
<td>A9.0</td>
</tr>
<tr>
<td>Reading Standards for Informational Text – RSIT (Standard Area, Grade Level, Standard #)</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td>A1.0, A2.0, A5.0, A8.0</td>
</tr>
<tr>
<td>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.</td>
<td>A1.0</td>
</tr>
<tr>
<td>Reading Standards for Literacy in History/Social Studies – RHSS (Standard Area, Grade Level, Standard #)</td>
<td></td>
</tr>
<tr>
<td>11-12.2. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.</td>
<td>A1.0, A2.0</td>
</tr>
<tr>
<td>11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.</td>
<td>A1.0</td>
</tr>
<tr>
<td>11-12.10. By the end of grade 12, read and comprehend history/social studies texts in the grades 11–12 text complexity band independently and proficiently.</td>
<td>A1.0, A2.0</td>
</tr>
<tr>
<td>Reading Standards for Literacy in Science and Technical Subjects – RLST (Standard Area, Grade Level, Standard #)</td>
<td></td>
</tr>
<tr>
<td>11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.</td>
<td>A1.0, A5.0, A9.0</td>
</tr>
</tbody>
</table>
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

| Reading Standards for Literacy in Science and Technical Subjects – RLST (Standard Area, Grade Level, Standard #) (continued) | PATHWAYS |
|---|---|---|---|---|
| **11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.** | A9.0 | B11.0 | C11.0 |
| **11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.** | A1.0, A9.0 | B9.0, B10.0, B11.0 | C1.0, C11.0 |
| **11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.** | A1.0, A5.0 | B1.0, B4.0, B5.0, B7.0, B8.0, B9.0 | C1.0, C4.0 | D1.0, D2.0, D3.0, D4.0, D3.0, D6.0 |

| 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.** | B11.0 |
| **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.** | A9.0 | B11.0 | C11.0 |
| **11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** | A9.0 | C11.0 |
| **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.** | A9.0 | C11.0 |
| **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.** | A9.0 | C11.0 |
| **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.** | A9.0 | C11.0 |
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>Writing Standards – WS (Standard Area, Grade Level, Standard #) (continued)</th>
<th>A. Architectural Design</th>
<th>B. Engineering Technology</th>
<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>A9.0</td>
<td></td>
<td>C11.0</td>
<td></td>
</tr>
</tbody>
</table>

### Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects – WHSST

| 11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. | A9.0 | | C11.0 |
| 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. | | | B1.0 |
| 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. | A9.0 | B1.0, B11.0 | C11.0 |
| 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. | | | B1.0 |
| 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 specific 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. | B1.0 | | |

### 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) | A2.0, A6.0 | B6.0, B10.0 | | D2.0 |
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

| Algebra – A-CED – Creating Equations (continued) | PATHWAYS |
|---|---|---|---|
| 2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. | A2.0, A6.0 | B6.0, B10.0 | D2.0 |
| 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. | A2.0, A6.0 | B6.0, B10.0 | D2.0 |
| 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 \( R \). | A6.0 | | |

### 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. | A2.0, A8.0 | B3.0, B10.0 | |
| 2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise. | A2.0, A8.0 | B3.0, B10.0 | |

*Solve equations and inequalities in one variable*

| 3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. | A2.0, A8.0 | B3.0, B10.0 | |
| 3.1 Solve equations and inequalities involving absolute value. (CA Standard Algebra I – 3.0 and CA Standard Algebra II – 1.0) | A2.0, A8.0 | B3.0, B10.0 | |

| 4. Solve quadratic equations in one variable. | | | |
| 4.1 Use the method of completing the square to transform any quadratic equation in \( x \) into an equation of the form \( (x - p)^2 = q \) that has the same solutions. Derive the quadratic formula from this form. | A8.0 | B3.0, B4.0, B10.0 | D7.0 |
| 4.2 Solve quadratic equations by inspection (e.g., for \( x^2 = 49 \)), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as \( a \pm bi \) for real numbers \( a \) and \( b \). | | | |
## Academic Alignment Matrix

**ENGINEERING AND ARCHITECTURE**

### Algebra – A-REI – Reasoning with Equations and Inequalities (continued)

#### Solve systems of equations

5. Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

6. Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

7. Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. For example, find the points of intersection between the line $y = -3x$ and the circle $x^2 + y^2 = 3$.

### Functions – F-IF – Interpreting Functions

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 $y = f(x)$.

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.

### PATHWAYS

<table>
<thead>
<tr>
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<th>D. Environmental Engineering</th>
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</thead>
<tbody>
<tr>
<td>A8.0</td>
<td>A8.0</td>
<td>B3.0, B10.0</td>
<td></td>
</tr>
<tr>
<td>A8.0</td>
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</tbody>
</table>
### Functions – F-LE – Linear, Quadratic, and Exponential Models

1. Distinguish between situations that can be modeled with linear functions and with exponential functions.
   a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.
   b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.
   c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

2. 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 \( y = (1.02)^t \), \( y = (0.97)^t \), \( y = (1.01)^{2t} \), \( y = (1.2)^{t/10} \), and classify them as representing exponential growth or decay.

### Functions – F-TF – Trigonometric Functions

1. Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.
   1.1 Understand the notion of angle and how to measure it, in both degrees and radians. Convert between degrees and radians. (CA Standard Trigonometry - 1.0)

2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.
### Functions – F-TF – Trigonometric Functions (continued)

3. (+) Use special triangles to determine geometrically the values of sine, cosine, tangent for $\frac{\pi}{3}$, $\frac{\pi}{4}$ and $\frac{\pi}{6}$, and use the unit circle to express the values of sine, cosine, and tangent for $\pi - x$, $\pi + x$, and $2\pi - x$ in terms of their values for $x$, where $x$ is any real number.

3.1 Know the definitions of the tangent and cotangent functions and graph them. (CA Standard Trigonometry – 5.0)

3.2 Know the definitions of the secant and cosecant functions and graph them. (CA Standard Trigonometry – 6.0)

5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.

6. (+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.

6.1 Know the definitions of the inverse trigonometric functions and graph the functions. (CA Standard Trigonometry – 8.0)

### Model periodic phenomena with trigonometric functions

- **A6.0**
- **B3.0, B4.0, B10.0**
- **C5.0, C10.0**
- **D7.0**

### Geometry – G-CO – Congruence

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.

13. Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.

### Geometry – G-GMD – Geometric Measurement and Dimensions

Explain volume formulas and use them to solve problems

5. Determine how changes in dimensions affect the perimeter, area, and volume of common geometric figures and solids.
### Academic Alignment Matrix

#### ENGINEERING AND ARCHITECTURE

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<tr>
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<th><strong>D. Environmental Engineering</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Apply geometric concepts in modeling situations</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>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).</td>
<td>A3.0, A5.0, A7.0, A8.0</td>
<td>B6.0, B10.0</td>
<td>C8.0, C9.0</td>
<td>D2.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Geometry – G-SRT – Similarity, Right Triangles, and Trigonometry</strong></th>
<th><strong>A. Architectural Design</strong></th>
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<th><strong>C. Engineering Design</strong></th>
<th><strong>D. Environmental Engineering</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Understand similarity in terms of similarity transformations</strong></td>
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</tr>
<tr>
<td>1. Verify experimentally the properties of dilations given by a center and a scale factor:</td>
<td>A3.0, A5.0, A7.0, A8.0</td>
<td>B2.0, B10.0</td>
<td>C3.0</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Number and Quantity – N-Q – Quantities</strong></th>
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<th><strong>C. Engineering Design</strong></th>
<th><strong>D. Environmental Engineering</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Reason quantitatively and use units to solve problems</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>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.</td>
<td>A2.0, A6.0, A8.0</td>
<td>B3.0, B4.0, B10.0</td>
<td></td>
<td>D7.0</td>
</tr>
<tr>
<td>2. Define appropriate quantities for the purpose of descriptive modeling.</td>
<td>A2.0, A6.0, A8.0</td>
<td>B3.0, B4.0, B10.0</td>
<td></td>
<td>D7.0</td>
</tr>
<tr>
<td>3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.</td>
<td>A2.0, A6.0, A8.0</td>
<td>B3.0, B4.0, B10.0</td>
<td>C4.0</td>
<td>D7.0</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Number and Quantity – N-VM – Vector and Matrix Quantities</strong></th>
<th><strong>A. Architectural Design</strong></th>
<th><strong>B. Engineering Technology</strong></th>
<th><strong>C. Engineering Design</strong></th>
<th><strong>D. Environmental Engineering</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Represent and model with vector quantities</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1. (+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., ( \mathbf{v} ), (</td>
<td>v</td>
<td>), ( |v| ), ( \mathbf{v} )).</td>
<td>A6.0</td>
<td>B5.0, B10.0</td>
</tr>
<tr>
<td>2. (+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.</td>
<td>A6.0</td>
<td>B5.0, B10.0</td>
<td>C8.0</td>
<td>D4.0, D5.0</td>
</tr>
<tr>
<td>3. (+) Solve problems involving velocity and other quantities that can be represented by vectors.</td>
<td>A6.0</td>
<td>B5.0, B10.0</td>
<td>C8.0</td>
<td>D4.0, D5.0</td>
</tr>
</tbody>
</table>
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>Number and Quantity – N-VM – Vector and Matrix Quantities (continued)</th>
<th>PATHWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perform operations on vectors</strong></td>
<td>A. Architectural Design</td>
</tr>
<tr>
<td>4. (+) Add and subtract vectors.</td>
<td>A6.0</td>
</tr>
<tr>
<td>a. Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes.</td>
<td></td>
</tr>
<tr>
<td>b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.</td>
<td></td>
</tr>
<tr>
<td>c. Understand vector subtraction ( \mathbf{v} - \mathbf{w} ) as ( \mathbf{v} + (-\mathbf{w}) ), where (-\mathbf{w}) is the additive inverse of (\mathbf{w}), with the same magnitude as (\mathbf{w}) and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise.</td>
<td></td>
</tr>
<tr>
<td>5. (+) Multiply a vector by a scalar.</td>
<td>A6.0</td>
</tr>
<tr>
<td>a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as (c(\mathbf{v}_1, \mathbf{v}_2) = (cv_1, cv_2)).</td>
<td></td>
</tr>
<tr>
<td>b. Compute the magnitude of a scalar multiple (cv) using (lcv) using (lcv) = (lcv). Compute the direction of (cv) knowing that when (lcv \neq 0), the direction of (cv) is either along (\mathbf{v}) (for (c &gt; 0)) or against (\mathbf{v}) (for (c &lt; 0)).</td>
<td></td>
</tr>
<tr>
<td><strong>Perform operations on matrices and use matrices in applications</strong></td>
<td></td>
</tr>
<tr>
<td>6. (+) Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network.</td>
<td>A6.0</td>
</tr>
<tr>
<td>7. (+) Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled.</td>
<td>A6.0</td>
</tr>
<tr>
<td>8. (+) Add, subtract, and multiply matrices of appropriate dimensions.</td>
<td>A6.0</td>
</tr>
<tr>
<td>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.</td>
<td>A6.0</td>
</tr>
<tr>
<td>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.</td>
<td>A6.0</td>
</tr>
</tbody>
</table>
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>Number and Quantity – N-VM – Vector and Matrix Quantities (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>12. (+) Work with 2 x 2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.</td>
</tr>
</tbody>
</table>

### Statistics and Probability – S-ID – Interpreting Categorical and Quantitative Data

<table>
<thead>
<tr>
<th>Summarize, represent, and interpret data on a single count or measurement variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Represent data with plots on the real number line (dot plots, histograms, and box plots).</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summarize, represent, and interpret data on two categorical and quantitative variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.</td>
</tr>
<tr>
<td>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 choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.</td>
</tr>
<tr>
<td>b. Informally assess the fit of a function by plotting and analyzing residuals.</td>
</tr>
<tr>
<td>c. Fit a linear function for a scatter plot that suggests a linear association.</td>
</tr>
</tbody>
</table>
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>Statistics and Probability – APPS – Advanced Placement Probability and Statistics</th>
<th>PATHWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Students solve probability problems with finite sample spaces by using the rules for addition, multiplication, and complementation for probability distributions and understand the simplifications that arise with independent events.</strong></td>
<td>A. Architectural Design</td>
</tr>
<tr>
<td><strong>2.0 Students know the definition of conditional probability and use it to solve for probabilities in finite sample spaces.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>3.0 Students demonstrate an understanding of the notion of discrete random variables by using this concept to solve for the probabilities of outcomes, such as the probability of the occurrence of five or fewer heads in 14 coin tosses.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>4.0 Students understand the notion of a continuous random variable and can interpret the probability of an outcome as the area of a region under the graph of the probability density function associated with the random variable.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>5.0 Students know the definition of the mean of a discrete random variable and can determine the mean for a particular discrete random variable.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>6.0 Students know the definition of the variance of a discrete random variable and can determine the variance for a particular discrete random variable.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>7.0 Students demonstrate an understanding of the standard distributions (normal, binomial, and exponential) and can use the distributions to solve for events in problems in which the distribution belongs to those families.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>8.0 Students determine the mean and the standard deviation of a normally distributed random variable.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>9.0 Students know the central limit theorem and can use it to obtain approximations for probabilities in problems of finite sample spaces in which the probabilities are distributed binomially.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>10.0 Students know the definitions of the mean, median and mode of distribution of data and can compute each of them in particular situations.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>11.0 Students compute the variance and the standard deviation of a distribution of data.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>12.0 Students find the line of best fit to a given distribution of data by using least squares regression.</strong></td>
<td>B.5.0</td>
</tr>
<tr>
<td><strong>13.0 Students know what the correlation coefficient of two variables means and are familiar with the coefficient’s properties.</strong></td>
<td>B.5.0</td>
</tr>
</tbody>
</table>
## Academic Alignment Matrix

### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>Statistics and Probability – APPS – Advanced Placement Probability and Statistics (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0 Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line graphs and bar graphs, stem–and–leaf displays, scatterplots, and box-and-whisker plots.</td>
</tr>
<tr>
<td>15.0 Students are familiar with the notions of a statistic of a distribution of values of the sampling distribution of a statistic. And of the variability of a statistic.</td>
</tr>
<tr>
<td>16.0 Students know basic facts concerning the relation between the mean and the standard deviation of a sampling distribution and the mean and the standard deviation of the population distribution.</td>
</tr>
<tr>
<td>17.0 Students determine confidence intervals for a simple random sample from a normal distribution of data and determine the sample size required for a desired margin of error.</td>
</tr>
<tr>
<td>18.0 Students determine the P-value for a statistic for a simple random sample from a normal distribution.</td>
</tr>
<tr>
<td>19.0 Students are familiar with the chi-square distribution and chi-square test and understand their uses.</td>
</tr>
</tbody>
</table>

### SCIENCE

<table>
<thead>
<tr>
<th>Scientific and Engineering Practices – SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asking questions (for science) and defining problems (for engineering)</td>
</tr>
<tr>
<td>2. Developing and using models</td>
</tr>
<tr>
<td>3. Planning and carrying out investigations</td>
</tr>
<tr>
<td>4. Analyzing and interpreting data</td>
</tr>
<tr>
<td>5. Using mathematics and computational thinking</td>
</tr>
</tbody>
</table>
### Scientific and Engineering Practices – SEP (continued)

<table>
<thead>
<tr>
<th>6. Constructing explanations (for science) and designing solutions (for engineering)</th>
<th>A. Architectural Design</th>
<th>B. Engineering Technology</th>
<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5.0</td>
<td>B3.0, B4.0, B5.0, B6.0, B10.0</td>
<td>C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0, C9.0</td>
<td>D5.0, D7.0</td>
<td></td>
</tr>
</tbody>
</table>

| 7. Engaging in argument from evidence | A9.0 | B3.0, B6.0, B10.0, B11.0 | C11.0 | D5.0, D7.0 |

| 8. Obtaining, evaluating, and communicating information | A2.0, A4.0, A5.0, A6.0, A7.0, A8.0, A9.0 | B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B9.0, B10.0, B11.0 | C3.0, C5.0, C6.0, C7.0, C8.0, C9.0, C10.0, C11.0 | D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0 |

### Crosscutting Concept – CC

| 1. Patterns | A2.0, A3.0, A7.0 | B3.0, B4.0, B5.0, B6.0, B8.0, B10.0 | D1.0, D2.0, D3.0, D4.0, D5.0 |
| 2. Cause and effect: Mechanism and explanation | A1.0, A5.0, A7.0 | B3.0, B4.0, B5.0, B6.0, B8.0, B10.0 | D2.0, D3.0, D4.0, D5.0, D6.0 |
| 3. Scale, proportion, and quantity | A1.0, A2.0, A3.0, A4.0, A5.0, A7.0, A8.0 | B1.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0, B10.0 | C2.0, C4.0, C5.0, C6.0, C7.0, C8.0, C9.0, C10.0 | D1.0, D2.0, D3.0, D4.0, D5.0, D6.0 |
| 4. Systems and system models | A5.0 | B3.0, B4.0, B5.0, B6.0, B8.0, B9.0, B10.0 | C7.0 | D2.0, D3.0, D4.0, D5.0, D6.0 |
| 5. Energy and matter: Flows, cycles, and conservation | A5.0 | B3.0, B4.0, B5.0, B10.0 | C2.0 | D2.0, D3.0, D4.0, D5.0, D6.0 |
| 6. Structure and function | A1.0, A2.0, A3.0, A5.0, A7.0, A8.0 | B6.0, B7.0, B8.0, B10.0 | C2.0 | D2.0, D5.0 |
| 7. Stability and change | A5.0, A7.0 | B3.0, B10.0 | C2.0 | D2.0, D3.0, D5.0, D6.0 |

### Physical Sciences – PS

**PS1: Matter and Its Interactions**
- **PS1.A: Structure and Properties of Matter**
  - A7.0 | B3.0, B4.0, B5.0, B10.0 | D2.0, D6.0 |
- **PS1.B: Chemical Reactions**
  - B4.0, B5.0, B10.0 | D2.0, D6.0 |
- **PS1.C: Nuclear Processes**
  - B4.0, B5.0, B10.0 | D6.0 |
<table>
<thead>
<tr>
<th>Physical Sciences – PS (continued)</th>
<th>PATHWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Architectural Design</td>
</tr>
<tr>
<td>PS2: Motion and Stability: Forces and Interactions</td>
<td></td>
</tr>
<tr>
<td>PS2.A: Forces and Motion</td>
<td>A6.0, A7.0</td>
</tr>
<tr>
<td>PS2.B: Types of interactions</td>
<td>A6.0, A7.0</td>
</tr>
<tr>
<td>PS2.C: Stability and Instability in Physical Systems</td>
<td>A1.0, A6.0, A7.0</td>
</tr>
<tr>
<td>PS3: Energy</td>
<td></td>
</tr>
<tr>
<td>PS3.A: Definitions of Energy</td>
<td>A5.0</td>
</tr>
<tr>
<td>PS3.B: Conservation of Energy and Energy Transfer</td>
<td>A5.0</td>
</tr>
<tr>
<td>PS3.C: Relationship Between Energy and Forces</td>
<td></td>
</tr>
<tr>
<td>PS3.D: Energy in Chemical Processes and Everyday Life</td>
<td>A5.0</td>
</tr>
<tr>
<td>PS4: Waves and Their Applications in Technologies for Information Transfer</td>
<td></td>
</tr>
<tr>
<td>PS4.A: Wave Properties</td>
<td>B3.0, B4.0, B5.0, B10.0</td>
</tr>
<tr>
<td>PS4.B: Electromagnetic Radiation</td>
<td>B4.0, B5.0, B10.0</td>
</tr>
<tr>
<td>PS4.C: Information Technologies and Instrumentation</td>
<td>B3.0, B4.0, B5.0, B10.0</td>
</tr>
<tr>
<td>Earth and Space Sciences – ESS</td>
<td></td>
</tr>
<tr>
<td>ESS2: Earth’s Systems</td>
<td></td>
</tr>
<tr>
<td>ESS2.A: Earth Materials and Systems</td>
<td>B3.0</td>
</tr>
<tr>
<td>ESS2.B: Plate Tectonics and Large-Scale System Interactions</td>
<td>B3.0</td>
</tr>
<tr>
<td>ESS2.C: The Roles of Water in Earth’s Surface Processes</td>
<td>B3.0</td>
</tr>
<tr>
<td>ESS2.D: Weather and Climate</td>
<td>B3.0</td>
</tr>
<tr>
<td>ESS2.E: Biogeology</td>
<td></td>
</tr>
</tbody>
</table>
### Academic Alignment Matrix

#### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>Earth and Space Sciences – ESS (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS3: Earth and Human Activity</td>
</tr>
<tr>
<td>ESS3.A: Natural Resources</td>
</tr>
<tr>
<td>ESS3.B: Natural Hazards</td>
</tr>
<tr>
<td>ESS3.C: Human Impacts on Earth Systems</td>
</tr>
<tr>
<td>ESS3.D: Global Climate Change</td>
</tr>
</tbody>
</table>

#### Engineering, Technology, and the Applications of Science – ETS

<table>
<thead>
<tr>
<th>ETS1: Engineering Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETS1.A: Defining and Delimiting an Engineering Problem</td>
</tr>
<tr>
<td>ETS1.B: Developing Possible Solutions</td>
</tr>
<tr>
<td>ETS1.C: Optimizing the Design Solution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ETS2: Links Among Engineering, Technology, Science, and Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETS2.A: Interdependence of Science, Engineering, and Technology</td>
</tr>
<tr>
<td>ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World</td>
</tr>
</tbody>
</table>

#### HISTORY/SOCIAL SCIENCE

#### Principles of American Democracy and Economics – AD

12.3 Students evaluate and take and defend positions on what the fundamental values and principles of civil society are (i.e., the autonomous sphere of voluntary personal, social, and economic relations that are not part of government), their interdependence, and the meaning and importance of those values and principles for a free society.

|                              | B9.0 | C1.0 | D2.0 |
### Principles of American Democracy and Economics – AD  (*continued*)

12.7 Students analyze and compare the powers and procedures of the national, state, tribal, and local governments.

<table>
<thead>
<tr>
<th>PATHWAYS</th>
<th>A. Architectural Design</th>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.0, A2.0, A5.0</td>
<td>B9.0</td>
<td>C1.0</td>
<td>D2.0</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.0</td>
<td></td>
<td></td>
<td>D10.0, D11.0, D13.0</td>
<td></td>
</tr>
</tbody>
</table>

### Principles of Economics – PE

12.1 Students understand common economic terms and concepts and economic reasoning.

<table>
<thead>
<tr>
<th>PATHWAYS</th>
<th>A. Architectural Design</th>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.0, A2.0, A5.0</td>
<td>B9.0</td>
<td>C1.0</td>
<td>D2.0, D3.0</td>
<td></td>
</tr>
</tbody>
</table>

12.1.4. Evaluate the role of private property as an incentive in conserving and improving scarce resources, including renewable and nonrenewable natural resources.

<table>
<thead>
<tr>
<th>PATHWAYS</th>
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<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>D10.0, D11.0, D13.0</td>
<td></td>
</tr>
</tbody>
</table>

12.2 Students analyze the elements of America’s market economy in a global setting.

<table>
<thead>
<tr>
<th>PATHWAYS</th>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.0, A5.0</td>
<td>B9.0</td>
<td>C1.0</td>
<td>D3.0</td>
<td></td>
</tr>
</tbody>
</table>

12.6 Students analyze issues of international trade and explain how the U.S. economy affects, and is affected by, economic forces beyond the United States’ borders.

<table>
<thead>
<tr>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.0</td>
<td>B9.0</td>
<td></td>
<td></td>
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</tbody>
</table>

### U.S. History and Geography – US

11.2 Students analyze the relationship among the rise of industrialization, large-scale rural-to-urban migration, and massive immigration from Southern and Eastern Europe.

<table>
<thead>
<tr>
<th>PATHWAYS</th>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.0</td>
<td></td>
<td>C1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11.5 Students analyze the major political, social, economic, technological, and cultural developments of the 1920s.

<table>
<thead>
<tr>
<th>PATHWAYS</th>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.0</td>
<td></td>
<td>C1.0</td>
<td></td>
<td></td>
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</tbody>
</table>

11.5.7. Discuss the rise of mass production techniques, the growth of cities, the impact of new technologies (e.g., the automobile, electricity), and the resulting prosperity and effect on the American landscape.

<table>
<thead>
<tr>
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<th>C. Engineering Design</th>
<th>D. Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.0</td>
<td></td>
<td>C1.0</td>
<td></td>
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</tbody>
</table>

11.6 Students analyze the different explanations for the Great Depression and how the New Deal fundamentally changed the role of the federal government.

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>A1.0, A5.0</td>
<td></td>
<td>C1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11.6.4. Analyze the effects of and the controversies arising from New Deal economic policies and the expanded role of the federal government in society and the economy since the 1930s (e.g., Works Progress Administration, Social Security, National Labor Relations Board, farm programs, regional development policies, and energy development projects such as the Tennessee Valley Authority, California Central Valley Project, and Bonneville Dam).
### Academic Alignment Matrix

#### ENGINEERING AND ARCHITECTURE

<table>
<thead>
<tr>
<th>U.S. History and Geography – US (continued)</th>
<th>PATHWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11.8 Students analyze the economic boom and social transformation of post-World War II America.</strong></td>
<td>A1.0, A2.0, A5.0</td>
</tr>
<tr>
<td><strong>11.11 Students analyze the major social problems and domestic policy issues in contemporary American society.</strong></td>
<td>A1.0, A2.0, A5.0</td>
</tr>
<tr>
<td><strong>11.11.5. Trace the impact of, need for, and controversies associated with environmental conservation, expansion of the national park system, and the development of environmental protection laws, with particular attention to the interaction between environmental protection advocates and property rights advocates.</strong></td>
<td></td>
</tr>
</tbody>
</table>

**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, A2.0, A5.0 | B9.0 | C1.0 |
| **10.9 Students analyze the international developments in the post-World World War II world.** | A1.0 | B9.0 | C1.0 |
| **10.10 Students analyze instances of nation-building in the contemporary world in at least two of the following regions or countries: the Middle East, Africa, Mexico and other parts of Latin America, and China.** | A5.0 | B9.0 | C1.0 |
| **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, A2.0, A3.0, A5.0 | B9.0 | C1.0 |

**Chronological and Spatial Reasoning – CSR**

| **1. Students compare the present with the past, evaluating the consequences of past events and decisions and determining the lessons that were learned.** | A1.0 | C1.0 |
| **2. Students analyze how change happens at different rates at different times; understand that some aspects can change while others remain the same; and understand that change is complicated and affects not only technology and politics but also values and beliefs.** | A1.0 | |
| **4. Students relate current events to the physical and human characteristics of places and regions.** | | C1.0 |
### Academic Alignment Matrix

<table>
<thead>
<tr>
<th>ENGINEERING AND ARCHITECTURE</th>
<th>PATHWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Architectural Design</td>
</tr>
</tbody>
</table>

#### Historical Research, Evidence, and Point of View – HR

4. Students construct and test hypotheses; collect, evaluate, and employ information from multiple primary and secondary sources; and apply it in oral and written presentations.

| HI | A1.0 |
|

#### Historical Interpretation – HI

1. Students show the connections, causal and otherwise, between particular historical events and larger social, economic, and political trends and developments.

2. Students interpret past events and issues within the context in which an event unfolded rather than solely in terms of present-day norms and values.

<table>
<thead>
<tr>
<th>HI</th>
<th>A1.0</th>
<th>C1.0</th>
</tr>
</thead>
</table>

**Historical Research, Evidence, and Point of View – HR**

4. Students construct and test hypotheses; collect, evaluate, and employ information from multiple primary and secondary sources; and apply it in oral and written presentations.

**Historical Interpretation – HI**

1. Students show the connections, causal and otherwise, between particular historical events and larger social, economic, and political trends and developments.

3. Students interpret past events and issues within the context in which an event unfolded rather than solely in terms of present-day norms and values.
Appendix: CTE Model Curriculum Standards Contributors

Engineering and Architecture

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Frank Zuidema, Instructor, Oceanside Unified School District
Robotics Engineering Proficiencies
(Please choose from the following proficiencies – not to exceed 35 lines)

1. Uses technical skills and academic knowledge.
2. Communicates effectively.
3. Researches, accesses and manages career-related resources.
4. Develops a career plan and life goals.
5. Accepts personal and responsible citizenship.

Demonstrates the following job skills:
6. Builds an electromechanical system such as a robot.
7. Predicts the output of systems which have AND, NOT, OR NOT, NAND, and XOR operations.
8. Identifies, understands the function of, manipulates, and assembles commonly used electromechanical components into a comprehensive robot system.

Introduction to Robotics Engineering Proficiencies
9. Understands the historical development in electricity and electronics.
10. Describes robotics technology applications including those for: scientific, medical, defense, rescue, production, manufacturing, transportation, service, and entertainment purposes.
11. Solves programs using common engineering practices.
12. Uses appropriate electronic test equipment and units of measure.
13. Demonstrates mathematical processes and applications that lead to solutions of electronic problems.
14. Describes the relationships between atomic structure of the atom, electricity, electronics, and the periodic table of elements.
15. Defines the Laws of Charges.
16. Identifies symbols and electronic component characteristics.
17. Determines resistor’s values by identifying color codes.
18. Understands the relationships between voltage, current, resistance, and power as pertaining to direct-current circuits.
19. Demonstrates ability to solve Direct-Current (DC) circuit analysis problems using Ohm’s Law.
21. Uses tools for their intended applications, performs electronic assembly work such as: soldering, stripping/crimping wire, routing wires, making wiring harnesses, and rendering electrical/electronic layouts.
22. Explains the major manufacturing processes.
23. Understands material classifications, characteristic, and testing in order to select appropriate materials for engineering products.
24. Determines what known information is relevant to a problem and analyzes options for the solution of the engineering problem.
25. Selects and finalizes the solutions and completes a working drawing (i.e. Mechanical, CAD, freehand drawings).
26. Understands the relationship between force, work, rate power, energy, resistance, and force transformers and demonstrates these principles on the engineering systems: mechanical, electrical, fluid, and thermal.
27. Gives a physical description of inductors and capacitors and describes how they function.
29. Draws a circuit diagram and layout the circuit.
30. Gives examples of common AC and DC systems.
31. Describes the use of computers in the following areas: interfacing to systems, data acquisition, and microcomputers in control systems.
32. Demonstrates knowledge of the single-chip microcomputer, including its programming model, instruction set, internal architecture, and how it interfaces with outside hardware.

Effective 2014-2015
Introduction to GIS
33. Use menu and toolbar functions to design basemaps.
34. Follow basic cartographic principles to design map layouts.
35. Export and print maps.
36. Explore and manage data using ArcCatalog.
37. Edit attribute table.
38. Join attribute tables.
39. Relate attribute tables.
40. Define a coordinate system.
41. Reproject data.
42. Create a geodatabase.
43. Create a feature class.
44. Query map data.
45. Create thematic maps.
46. Locate street data on the Internet.
47. Create an address locator.
48. Geocode an address.
49. Edit metadata.
50. Create graphs.

Advanced Robotics Engineering Proficiencies
51. Understands present and future applications for Robotics Technology, which has a role in space science and medical advancements.
52. Describes the use of electronic test equipment and units of measure.
53. Solves Direct-Current (DC) circuit analysis problems using Ohm’s Law.
54. Solves multi-step problems including word problems using linear equations in one variable.
55. Measures current, voltage, and resistance in various segments of parallel and series circuits.
56. Measures digital circuits with oscilloscope.
57. Conducts laboratory experiments which include detailed problem, theory, results, and discussion sections including the use of lab equipment for measurement.
58. Constructs an electronic device following a schematic diagram as a sole reference utilizing the Electronics Learning Lab utilizing integrated circuits, capacitors, resistors, switches, LEDs, and wire.
59. Uses appropriate manufacturing processes to produce an actual product.
60. Demonstrates the application of computerized controllers to operate machinery, equipment, and processes.
61. Describes the use and application of hydraulic, pneumatic, and mechanical controls in a robot system.
62. Demonstrates the ability to select and utilize the proper measurement tool based on the product and required tolerance.
63. Performs unit conversions between systems such as metric and traditional English based measurements.
64. Understands the impact and importance of environmental issues related to manufacturing processes and organizations.
65. Describes the uses and the requirements that material selection place on the manufacturing methods and processes.
66. Understands the actual cost in time, material, and tooling expenses related to the product manufacturing cycle.
67. Describes the different aspects of manufacturing management that includes personal time management, team participation/dynamics, and scheduling priorities.
68. Reads and interprets technical drawings accurately.
69. Interfaces technical information between computers, machine controllers, and machinery.
70. Selects and finalizes the solutions and completes a working drawing (i.e. Mechanical, CAD freehand drawings).
71. Uses appropriate materials, tools, and processes to fabricate a model (form) of the solution.
72. Prepares a three-view drawing of the design showing the subsystem layout.
73. Builds, tests, and redesigns a prototype.
74. Understands the relationships between force, work, rate, power, energy, resistance, and force transformers and demonstrates these principles on the engineering systems: mechanical, electrical, fluid, and thermal.
75. Applies the universal technology systems model (input, process, output, and feedback) in a robotics-manufacturing environment.
76. Illustrates how systems are planned, designed, constructed, and applied to perform a task.
77. Assembles and programs the Toddler Robot.
78. Determines current, voltage, and logic of a given system.
79. Writes a block diagram for a given system detailing the control logic of the circuit and its effect on the mechanical portion of the system.
80. Demonstrates knowledge of the single-chip microcomputer, including its programming model, instruction set, internal architecture, and how it interfaces with outside hardware.