Instructional Framework

Engineering

15.0000.00

This Instructional Framework identifies, explains, and expands the content of the standards/measurement criteria, and, as well, guides the development of multiple-choice items for the Technical Skills Assessment. This document corresponds with the Technical Standards endorsed on January 27, 2021.

Domain 1: Engineering Math and Science Principles **Instructional Time: 45 - 50%**	
STANDARD 3.0 APPLY MATHEMATICAL LAWS AND PRINCIPLES RELEVANT TO ENGINEERING TECHNOLOGY	
3.1 Use basic mathematical functions and tools (i.e., Google Sheets, Excel, graphing calculator, etc.)	• Spreadsheets • Graphing calculator • Programmable controllers
3.2 Use data collection and analysis to display data and verify its accuracy	• Spreadsheets • Formula entry • Multiple graphs and entry • Data sorting • Programmable controllers
3.3 Display data graphically using diagrams and working drawings	• Virtual prototyping and simulations • Produce drawings and types • Spreadsheets • Multiple graphs and entry • Kinematic graphs (e.g., d, v, and a) • Data tables, charts
3.4 Use statistical measures of a central tendency (mean, median, and mode) as needed in the structured problem-solving process	• Mean • Median • Mode • Standard deviation

3.5 Use mathematical models including algebraic, geometric, trigonometric, and calculus relationships to solve, analyze, and design solutions	● Sin/Cos/Tangent and inverse calculation and meaning ● Algebraic substitution, order of operation, and solutions to systems of equations ● Formula manipulation/Rearranging equations
3.6 Generate manually and electronically mathematical solutions and evaluate their validity	● Test reporting ● Quality control documentation ● Circuit Theory ● Thermodynamics ● Forces/Trusses ● Fluid mechanics ● Simple machines ● Power and energy equations ● Kinematics
3.7 Use English and Metric systems of measurement	● Unit conversions ● Unit notation ● Tolerances and Fit ● US Customary System ● Metric System/SI
STANDARD 4.0 APPLY SCIENTIFIC LAWS AND PRINCIPLES RELEVANT TO ENGINEERING TECHNOLOGY	
4.1 Use the relationship among energy, work, and power to solve a variety of problems involving mechanical, fluid, electrical, and thermal systems	● Mechanical ○ Simple machines ○ Mechanical power ● Electrical ○ Ohm's Law ○ Kirchhoff's Law ○ Circuit analysis ○ Electrical power ● Chemical ○ Fluids ○ Thermal systems ○ Hydraulics ● Civil ○ Forces ○ Trusses ○ Torque/Moments

	● Efficiency and power
4.2 Use Newton's Laws of Motion to analyze static and dynamic systems with and without the presence of external forces	● Newton's Laws of Motion ○ Free body diagrams ○ Force/Mass/Acceleration relationships ○ Statics/Truss analysis ○ Kinematics - projectile motion ○ Rigid body ○ Equilibrium ○ Momentum ○ Structural member properties ○ Vectors ○ Dynamics
4.3 Use the laws of conservation of energy, charge, and momentum to solve a variety of problems involving mechanical, fluid, electrical, and thermal systems	● Thermodynamics ● Momentum ● Electrical charge ● Energy ○ Potential ○ Kinetic ○ Work ○ Power ○ Efficiency ○ Conservation
4.4 Analyze relevant properties of materials used in engineering projects [i.e., chemical, environmental, mechanical (tension, compression, torque), electrical, physical, etc.]	● Chemical ● Environmental ● Mechanical ○ Tension ○ Compression ○ Torque ● Electrical ○ Electrical conductivity ● Physical ○ Density ○ Specific gravity ● Thermodynamic ○ Heat transfer properties

Domain 2: Engineering Tools **Instructional Time: 30 - 40%**	
STANDARD 2.0 CREATE ENGINEERING SOLUTIONS BY APPLYING A STRUCTURED PROBLEM-SOLVING/DECISION- MAKING PROCESS	
2.1 Identify the problem	● Problem valid and justifiable ● Problem identification ● Brainstorm ● Stakeholder ● Documentation
2.2 Develop a problem statement based on facts, research, and experience	● Problem validation ● Research ● Documentation
2.3 Explore possible issues or options to the problem	● Research ○ Existing solutions ○ Potential stakeholders ● Establish criteria and constraints ● Solutions ○ Alternatives ○ Drawbacks ○ Documentation
2.4 Select the best solution within the constraints and criteria	● Solution ○ Criteria ○ Constraints ○ Scientific principles ○ Potential impacts on people and the environment ● Develop a design proposal ○ Decision Matrix ○ Design of Experiments ● Documentation
2.5 Develop a prototype or model to test the selected solution	● Prototype ● Make a model ● Technical drawings

	• Documentation
2.6 Implement the solution	• Test and evaluate • Iterative • Quality control ○ Safety • Documentation
2.7 Evaluate the solution, and revise or repeat if necessary (i.e., Are there other solutions, better solutions, or cheaper solutions? etc.)	• Refine the design • Review problem statement • Select the solution • Documentation

2.8 Document and report all results	• Communicate
	  ○ Status
	  ○ Assumptions
	  ○ Results
	  ○ Conclusions
	• Report writing
	• Present solution
	• Project portfolio

STANDARD 5.0 APPLY TECHNOLOGY AND TOOLS TO ENGINEERING SOLUTIONS	
5.1 Explain the concepts of precision, accuracy, and tolerance as they relate to measurement tools (i.e., micrometers, dial indicator, digital calipers, etc.)	• Micrometers • Dial indicator • Digital calipers • Tolerances • Standard deviation • Precision • Accuracy
5.2 Use measurement devices such as calipers, oscilloscopes, and digital multimeters to gather data for analysis	• Use precision and accuracy with measurement devices (micrometer and caliper) • Use measuring devices to gather data (e.g., ruler, tape measure, multimeter, and graduated cylinder) • Physical and Virtual Models • Calipers

	● Oscilloscope ● Digital multimeter ○ Voltage ○ Current ○ Resistance ○ Probes ● Video analysis
5.3 Verify the calibration status of measurement tools (i.e., quality control, test, and retest, etc.)	● Quality control ● Test ● Retest
5.4 Use software tools to solve, model, analyze, and/or design solutions to engineering problems (i.e., SOLIDWORKS, AutoCAD, On-shape, Fusion360, Google Sheets, Excel, etc.)	● Software tools ○ SOLIDWORKS ○ AutoCAD ○ On-shape ○ Fusion360 ○ Google Sheets ○ Excel ○ Tinkercad ○ Arduino programmable controllers ○ Raspberry-Pi programmable controllers ○ Applicable software development ○ Ladder Logic
5.5 Identify hazards, risks, and incidents related to tools and equipment	● Safety regulations ● OSHA knowledge ● General equipment safety rules ● Fire safety ● SDS ● Hazards ● Safety protocols
5.6 Practice safe use of tools, machines, equipment, and materials (i.e., OSHA, SDS sheets, PPE, etc.)	● OSHA ● SDS sheets ● PPE

5.7 Review fabrication methods to create potential solutions to engineering problems (e.g., 3D printing, injection molding, woodworking, and welding)	• 3D printing
	• Injection molding
	• Woodworking
	• Welding - virtual
	• Soldering
	• Applicable Software Development
	• Design for Manufacturing (DFM)
	  ○ Prototypes
	  ▪ CNC
	  ▪ 3D printer

Domain 3: Engineering Project Management **Instructional Time: 20 - 25%**	
STANDARD 6.0 APPLY COMMUNICATION SKILLS TO ENGINEERING PROJECTS	
6.1 Apply technical writing skills and use visual aids to present critical information in reports (i.e., results/outcomes, conclusions, future work recommendations, etc.)	• Proposal • Budget • Results/Outcomes • Conclusions • Future work recommendations • Visual aids
6.2 Utilize the three stages of oral presentation (e.g., planning, practicing, and presenting)	• Planning • Practicing • Presenting
6.3 Apply communication skills, including listening skills, with project teams, project managers, clientele, and/or contractors	• Effective communication • Use of soft skills
6.4 Explain the importance of multiculturalism in creative and professional decision-making (e.g., better decisions based on different views, perspectives, ideas, and proposals; fosters critical thinking, analysis, and collaboration)	• Better decisions based on different views, perspectives, ideas, and proposals • Fosters critical thinking, analysis, and collaboration

STANDARD 7.0 APPLY PROJECT MANAGEMENT TOOLS AND TECHNIQUES TO ENGINEERING SOLUTIONS	
7.1 Determine the tools, materials, manpower, and money allocation required to manage the project	● Resource allocation ● Project management ● Process groups ● Managing a project ○ Scope ○ Time constraints ○ Success criteria ○ Goals ○ Types of resources
7.2 Utilize time-management techniques (e.g., prioritizing and planning, creating goals, scheduling, advocating, and taking action)	● Prioritizing and planning ● Creating goals ● Scheduling ● Advocating (delegating/recommending) ● Taking action ● Balancing competing project constraints
7.3 Organize and maintain work using project management tools (e.g., Gantt Chart, AGILE, Kanban, Waterfall model, dashboards, task lists, project reports, and time sheets)	● AGILE ● Kanban ● Waterfall model ● Dashboards ● Task lists ● Project reports ● Time sheets
7.4 Schedule daily/weekly meetings to check status of the project and to deal with any constraints and obstacles to the project	● Update project management tools ○ Monitor and forecast completion costs and project progress
7.5 Document and present project results/outcomes as appropriate	● Data table formats ● Inferences and conclusions from data tables ● Verbal presentation ● Multimedia presentation methods ● Written reporting ○ Grammar ○ Effective language

7.6 Analyze the project from various perspectives (i.e., sustainability, political, economic, health and safety perspectives, etc.)	● Sustainability
	● Political
	● Economic
	● Health and safety
	● Project evaluation
	  ○ Project viability
	  ○ Successes
	  ○ Failures
	  ○ Lessons learned

Domain 4: Engineering in a Global Society
Instructional Time: 5 - 10%

STANDARD 1.0 INVESTIGATE THE FIELD OF ENGINEERING TO ADDRESS THE NEEDS OF A GLOBAL SOCIETY

1.1 Define the disciplines of engineering (types of engineers) (i.e., chemical, civil, electrical, mechanical, agricultural, industrial, aeronautical, software, biomedical, etc.)	● Careers
	  ○ Chemical
	  ○ Civil
	  ○ Electrical
	  ○ Mechanical
	  ○ Agricultural
	  ○ Industrial
	  ○ Aeronautical
	  ○ Software
	  ○ Biomedical
	● Preconceptions about engineering
	● Engineering interconnections (interdependency of engineering disciplines)
	● Need for engineers

1.2 Recognize that engineers solve a wide range of problems involving innovation, cost reduction, and more efficient/effective processes	● Problem solving
	● Project management
	  ○ Innovation
	  ○ Cost reduction
	  ○ Project efficiency
	  ○ Research

1.3 Describe the specialties/areas of training that may lead to jobs/careers (i.e., transportation, construction, research and development, analytical design, disaster management, waste management, environmental, automation and robotics, etc.)	● Specialty Areas ○ Civil Engineering ▪ Transportation ▪ Construction ▪ Waste management ○ Disaster management ○ Environmental ○ Research and development ○ Analytical design ○ Automation and robotics ○ Nuclear ● Areas of training ○ University ○ Associate degree ○ Apprenticeships ○ Certifications
1.4 Explore emerging fields in engineering and challenges to future work and future life [i.e., drones, electric cars, autonomous cars, AI, IoT, Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Additive Manufacturing (AM), Smart City design, Automation, Machine Learning (ML), M2M (Machine-to-Machine), H2M (Human-to-Machines), etc.]	● Emerging Fields ○ Drones ○ Electric cars ○ Autonomous cars ○ AI ○ IoT ○ Virtual Reality (VR) ○ Augmented Reality (AR) ○ Mixed Reality (MR) ○ Additive Manufacturing (AM) ○ Smart City design ○ Automation ○ Machine Learning (ML) ○ M2M (Machine-to-Machine) ○ H2M (Human-to-Machines)
1.5 Analyze the societal, environmental, legal, and ethical responsibilities of engineers (e.g., Engineering Code of Ethics, economic, political, sustainability, and community health and safety)	● Engineering Code of Ethics ● Economic ● Political ● Sustainability ● Community health and safety ○ OSHA

1.6 Determine the skills and education required to enter engineering careers (i.e., aptitude for math and science; complex problem-solving, critical thinking and decision-making; interpreting plans, schematics, and blueprints; communication skills to influence and convey facts with specificity, etc.)	● Aptitude for math and science
	● Complex problem-solving
	● Critical thinking and decision-making
	● Interpreting plans
	  ○ Schematics
	  ○ Blueprints
	● Software manipulation
	  ○ Programming
	● Communication skills to influence and convey facts with specificity