Engineering
15.0000.00
Embedded Math Credit Crosswalk

The Engineering program has been recognized by the Arizona State Board of Career and Technical Education (CTE) is eligible for consideration by local governing boards to grant 1 credit of 4th-year high school math. This document is the result of a committee analysis completed in May 2023.

Note: AZ High School Math Standards are highlighted in yellow

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.)

1.2 Recognize that engineers solve a wide range of problems involving innovation, cost reduction, and more efficient/effective processes

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.)

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.]

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)

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.)

STANDARD 2.0 CREATE ENGINEERING SOLUTIONS BY APPLYING A STRUCTURED PROBLEM-SOLVING/DECISION-MAKING PROCESS

2.1 Identify the problem

2.2 Develop a problem statement based on facts, research, and experience

2.3 Explore possible issues or options to the problem

2.4 Select the best solution within the constraints and criteria

Algebra 1 A1.A-CED.A.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.

Algebra 2 A2.F-IF.B.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Include problem solving opportunities utilizing a real-world context.

Rationale: Collect data including quality control statistics Evaluate mean-median-mode (std deviation). Examples include building a solar oven and systems optimized using inequalities and a system of two equations.

2.5 Develop a prototype or model to test the selected solution

Algebra 1 A1.A-CED.A.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.
Quantitative Reasoning QR.CR.3 Identify, create, and use appropriate models for bivariate data sets (i.e. linear, exponential) to estimate solutions for contextual questions, identify patterns and identify how changing parameters affect the models.
Rationale: Model and make modifications to find different solutions. Recalculate and prototype data by testing unknowns with equations and expressions.

2.6 Implement the solution

2.7 Evaluate the solution, and revise or repeat if necessary (i.e., Are there other solutions, better solutions, or cheaper solutions? etc.)

Algebra 1 A1.S-ID.A.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.
Quantitative Reasoning QR.CR.3 Identify, create, and use appropriate models for bivariate data sets (i.e. linear, exponential) to estimate solutions for contextual questions, identify patterns and identify how changing parameters affect the models.

Rationale: Graph data and compare to quality control statistics.

2.8 Document and report all results

Algebra 1 A2.F-IF.B.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Include problem solving opportunities utilizing a real-world context.
Rationale: Interpret and explain graph data.

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.)

Algebra 1 A1.F-BF.A.1 Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from real-world context. Focus on linear, quadratic, exponential and piecewise-defined functions (limited to absolute value and step).
Quantitative Reasoning QR.NR.3 Understand and compare magnitudes of numbers utilizing real-world context. Understand the importance and impact of unit selection.
Rationale: Apply mathematical models and perform calculations manually before using software tools. Then, create software simulations to code/create functions.

3.2 Use data collection and analysis to display data and verify its accuracy

Quantitative Reasoning QR.SPR.2 Analyze statistical information and identify limitations, strengths, or lack of information in studies including data collection methods (e.g. sampling, experimental, observational) and possible sources of bias. Identify errors or misuses of statistics to justify particular conclusions.
Quantitative Reasoning QR.SPR.4 Represent center, shape, and spread of two or more data sets. Reason, communicate, and compare data sets in context.
Rationale: Prototype analysis using scatter plots and histograms.

3.3 Display data graphically using diagrams and working drawings

Algebra 1 A1.A-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
Algebra 2 A2.F-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Functions include linear, quadratic, exponential, polynomial, logarithmic, rational, sine, cosine, tangent, square root, cube root and piecewise-defined functions.
Rationale: Use Ohm's law relationship graphing V=IR students. Related projects include Rocket Launch to analyze data trends by graphing mass compared to distance/height traveled and center of gravity location to distance/height traveled. Motorized Gutter Boats - top speed and elapsed time calculated Measure the voltage and resistance relationship in an inverse relationship graph using a modeling equation to derive the relationship. Cardboard boat project - volume, depth, and surface area

3.4 Use statistical measures of a central tendency (mean, median, and mode) as needed in the structured problem-solving process

Algebra 2 A2.S-ID.A.4 Use the mean and standard deviation of a data set to fit it to a normal curve and use properties of the normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, or tables to estimate areas under the normal curve.
Rationale: Calculate standard deviation and tolerances. A related project could be building a 3D design of puzzle pieces and wooden cubes.

3.5 Use mathematical models including algebraic, geometric, trigonometric, and calculus relationships to solve, analyze, and design solutions

Algebra 2 A2.F-BF.B.4 Find inverse functions. a. Understand that an inverse function can be obtained by expressing the dependent variable of one function as the independent variable of another, recognizing that functions f and g are inverse functions if and only if f(x) = y and g(y) = x for all values of x in the domain of f and all values of y in the domain of g. b. Understand that if a function contains a point (a,b), then the graph of the inverse relation of the function contains the point (b,a). c. Interpret the meaning of and relationship between a function and its inverse utilizing real-world context.
Algebra 2 A2.F-IF.B.6 Calculate and interpret the average rate of change of a continuous function (presented symbolically or as a table) on a closed interval. Estimate the rate of change from a graph. Include problem-solving opportunities utilizing real-world context. Functions include linear, quadratic, exponential, polynomial, logarithmic, rational, sine, cosine, tangent, square root, cube root and piecewise-defined functions.
Algebra 2 A2.F-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
Algebra 2 A2.A-REI.C.7 Solve a 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 x2+y2 = 3.
Rationale: Create an algebraic equation to determine buoyancy (cargo mass), calculate percent of error tested, and explain results. Related projects: Cardboard Boat -Calculate the speed of a robot based on the RPM of the motor and the gear ratio. Convert RPM (circular distance) to a linear distance using the circumference of a wheel. Robot Combination of parallel and series circuits to determine all values given with only few variables. Arduinos -Determine system of equations and Inequalities, quadratic, and nonlinear functions. Build Solar Ovens.

Geometry G.G-C.B.5 Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector. Convert between degrees and radians.
Geometry G.G-GPE.B.7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles.
Geometry G.G-SRT.C.7 Explain and use the relationship between the sine and cosine of complementary angles.
Geometry G.G-SRT.C.8 Use trigonometric ratios (including inverse trigonometric ratios) and the Pythagorean Theorem to find unknown measurements in right triangles utilizing real-world context.
Rationale: Determine the volume of cylinder and cone. Related projects: Cardboard Boat -Determine the relationship of sine cosine of a complementary angle. Robot (gears) -Design an image with circle and arcs using degrees and radians. Area of the sector-coding unit of geometrical shapes. 3D Image -Create a rocket cone of by folding a cylinder shape. Project: Create Origami.
Precalculus RFR.AF.1 Interpret parameters of a function defined by an expression in the context of the situation.
Precalculus RFR.AF.2 Sketch the graph of a function that models a relationship between two quantities, identifying key features.
Precalculus RFR.AF.3 Interpret key features of graphs and tables for a function that models a relationship between two quantities in terms of the quantities.
Precalculus RFR.ETT.1 Model real-world situations involving trigonometry.
Precalculus RFR.ETT.2 Apply the Law of Sines and Law of Cosines to solve problems. RV.EV.1 Recognize vector quantities as having both magnitude and direction.
Precalculus RV.EV.2 Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes.
Precalculus RV.EV.4 Solve problems involving velocity and other quantities that can be represented by vectors.
Quantitative Reasoning QR.CR.2 Compare, reason and communicate about proportional and non-proportional models utilizing real-world contexts.
Rationale: Calculate the height of a rocket from a known distance and angle. A related project is rockets.
Examine vector forces, use transversal lines to determine the angle of the ramp to that of the robot. Calculate torque required to go up the ramp with determining the friction coefficient. Related projects: Vector Robots, Gliders, Robot Gear train challenge, Cardboard Boats, Trebuchets, CO2 Cars, Solar oven, Rockets, Coding 3D images, and determining parabolic trajectory of rocket and parachute.

3.6 Generate manually and electronically mathematical solutions and evaluate their validity

Same Math Standards listed in 3.5.

3.7 Use English and Metric systems of measurement

Algebra 2 A2-N-Q.A.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, include utilizing real-world context.
Geometry G.N-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities utilizing real-world context.
Quantitative Reasoning QR.NR.3 Understand and compare magnitudes of numbers utilizing real-world context. Understand the importance and impact of unit selection.
Rationale: Solve multi-step problems with conversion calculations. Related projects include Bridge measurements given in IPS and then converted to Metric, 3D printing designed in IPS and converted to Metric, Vex Robotics motor torque calculations are done in metric, Solar Oven conversions from IPS to metric or even cm/mm to meters, Electrical unit Watts to Kilowatts, Barge project IPS to metric system, Fluid Dynamics - Linear Kinematics, CO2 Car Project -Torque Wrench Calculations -Water Distribution -Calculate predicted distance travel and determine percentage of error, and Mouse Trap Car.

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

Same Math Standards and Rationale as 3.5

4.2 Use Newton's Laws of Motion to analyze static and dynamic systems with and without the presence of external forces

Same Math Standards and Rationale as 3.5 and 3.7

Rationale: Nonlinear systems are solved algebraically and graphed. Related projects include Bridge Design, Mouse Trap, and CO2 Car .

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

Same Math Standards and Rationale as 3.5

4.4 Analyze relevant properties of materials used in engineering projects [i.e., chemical, environmental, mechanical (tension, compression, torque), electrical, physical, etc.]

Same Math Standards as 3.5

Rationale: Understand material properties, perform unit conversions, and solve multi-step problems. Related projects include Solar Oven and Bridge Design.

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.)

Same Math Standards as 3.5

Rationale: Measure and run statistical analysis to determine acceptable tolerances. Discuss concepts of precision and accuracy. Determine tolerances margin of error, use a mathematical model to determine accurate measurements in the CAD software to create precision print. A related project is Puzzle Cube.

5.2 Use measurement devices such as calipers, oscilloscopes, and digital multimeters to gather data for analysis

5.3 Verify the calibration status of measurement tools (i.e., quality control, test, and retest, etc.)

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.)

Same Math Standards and Rationale as 3.5

5.5 Identify hazards, risks, and incidents related to tools and equipment

5.6 Practice safe use of tools, machines, equipment, and materials (i.e., OSHA, SDS sheets, PPE, etc.)

5.7 Review fabrication methods to create potential solutions to engineering problems (e.g., 3D printing, injection molding, woodworking, and welding)

Same Math Standards and Rationale as 3.5

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.)

Same Math Standards as 3.5

Rationale: All technical reports include the student explanation of how equations were derived and used within each of their projects.

6.2 Utilize the three stages of oral presentation (e.g., planning, practicing, and presenting)

Same Math Standards as 3.5

Rationale: All presentations include the student explanation of how equations were derived and used within each of their projects.

6.3 Apply communication skills, including listening skills, with project teams, project managers, clientele, and/or contractors

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)

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

7.2 Utilize time-management techniques (e.g., prioritizing and planning, creating goals, scheduling, advocating, and taking action)

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)

7.4 Schedule daily/weekly meetings to check status of the project and to deal with any constraints and obstacles to the project

7.5 Document and present project results/outcomes as appropriate

7.6 Analyze the project from various perspectives (i.e., sustainability, political, economic, health and safety perspectives, etc.)