# Scope & Sequence

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| Course Name: Engineering Mathematics **TSDS PEIMS Code:** 13036700 | | | **Course Credit:** 1.0  **Course Requirements:** Recommended for students in Grades 11-12.  **Prerequisites:** Algebra II. |
| **Course Description:** Engineering Mathematics is a course where students solve and model design problems. Students will use a variety of mathematical methods and models to represent and analyze problems that represent a range of real-world engineering applications such as robotics, data acquisition, spatial applications, electrical measurement, manufacturing processes, materials engineering, mechanical drives, pneumatics, process control systems, quality control, and computer programming. This course satisfies a high school mathematics graduation requirement. | | | |
| **NOTE:** This is a suggested scope and sequence for the course content. This content will work with any textbook or instructional materials. If locally adapted, make sure all TEKS are covered. | | | |
| **Total Number of Periods**  **Total Number of Minutes**  **Total Number of Hours** | 175 Periods  7875 Minutes  131.25 Hours | \*Schedule calculations based on 175/180 calendar days. For 0.5 credit courses, schedule is calculated out of 88/90 days. Scope and sequence allows additional time for guest speakers, student presentations, field trips, remediation, extended learning activities, etc. | |
| **Unit Number, Title, and Brief Description** | **# of Class Periods\***  (assumes 45-minute periods)  Total minutes per unit | **TEKS Covered**  **130.413. (c) Knowledge and Skills** | |
| **Unit 1: Mathematics in Engineering**  Career and technical education instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions. In this unit, the student will use mathematical processes and models to solve real-world problems. The culminating activity for this unit will have students analyze mathematical relationships and create representations to organize, record, and communicate mathematical ideas. | 15 Periods  675 Minutes | (2) The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:  (A) apply mathematics to problems arising in everyday life, society, and the workplace;  (B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution;  (C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems;  (D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language;  (E) create and use representations to organize, record, and communicate mathematical ideas;  (F) analyze mathematical relationships to connect and communicate mathematical ideas; and  (G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. | |
| **Unit 2: Mathematically Based Hydraulics Concepts**  The Science, Technology, Engineering, and Mathematics (STEM) Career Cluster focuses on planning, managing, and providing scientific research and professional and technical services, including laboratory and testing services, and research and development services. This unit explores the differences of pressure versus cylinder force, and flow rate verses cylinder speed. Students will perform such activities such as calculate, measure, and illustrate the force output and speed of an extending and retracting cylinder. The culminating activity for this unit will be to determine and depict the stroke time of a cylinder in gallons per minute. | 15 Periods  675 Minutes | (3) The student uses mathematically based hydraulics concepts to measure and find pump output, understand pressure versus cylinder force, and understand flow rate verses cylinder speed. The student is expected to:  (A) explain how flow rate can be measured in gallons per minute and liters per minute;  (B) calculate and record data using actual flow rates from a flow meter chart;  (C) calculate, measure, and illustrate the force output and speed of an extending and retracting cylinder; and  (D) determine and depict the stroke time of a cylinder in gallons per minute. | |
| **Unit 3: Mathematical Concepts of Structure Design**  In this unit, students will apply concepts of moments and bending stress and concepts of truss design and analysis. From calculating the magnitude of force applied to a rotational system to illustrating a bending moment on a beam, this unit culminates with students designing factors of safety to column and beam design. | 15 Periods  675 Minutes | (4) The student uses mathematical concepts of structure design to define and describe statics, acquire data, apply concepts of moments and bending stress, and apply concepts of truss design and analysis. The student is expected to:  (A) calculate a resultant force;  (B) apply the concept of equilibrium to force calculations;  (C) calculate a force using a free-body diagram;  (D) develop an application of strain gauges that determines mathematically and experimentally the force on a structural element;  (E) calculate the magnitude of force applied to a rotational system;  (F) apply the moment equilibrium equation to force calculations;  (G) calculate, measure, and illustrate a bending moment on a beam;  (H) determine and depict the bending stress in a beam;  (I) calculate forces in truss using a six-step problem-solving method;  (J) apply modulus of elasticity to the deflection of beams;  (K) calculate a beam deflection for a given load;  (L) determine and depict the critical load for buckling using Euler's formula; and  (M) design and apply factors of safety to column and beam design. | |
| **Unit 4: Trigonometry in Spatial Applications**  In this unit, students will select appropriate tools such as real objects, manipulatives, paper and pencil, and technology and techniques such as mental math, estimation, and number sense to solve problems. Students will effectively apply trigonometric ratios, including sine, cosine, and tangent, to spatial problems. | 15 Periods  675 Minutes | (5) The student understands the role of trigonometry in spatial applications. The student is expected to:  (A) apply trigonometric ratios, including sine, cosine, and tangent, to spatial problems; and  (B) determine the distance and height of remote objects using trigonometry. | |
| **Unit 5: Multi-View Computer-Aided Drafting and Design**  Students will use mathematical relationships to generate solutions and make connections and predictions. In this unit, students will engage in activities such as analyzing mathematical relationships to determine a dimension of an object given a scaled drawing having no dimensions, create a method to determine the direction of a gear train's output shaft, and design a gate size in an injection mold system using the gate width and depth formulas. | 15 Periods  675 Minutes | (6) The student understands the concepts of design processes with multi-view computer-aided drafting and design drawings for facilities layouts, precision part design, process design, injection mold design, and computer-aided manufacturing, as applied to processes using 3D printing, laser cutting, and computer numerical control. The student is expected to:  (A) determine a dimension of an object given a scaled drawing having no dimensions;  (B) compare and contrast the function of production time and production rate;  (C) calculate and apply the proper cycle time and analyze machines required to meet a specified production rate;  (D) demonstrate the calculation and application of output shaft speed and torque in a gear train;  (E) create a method to determine the direction of a gear train's output shaft;  (F) design a spur gear train given speed and torque requirements;  (G) calculate and apply the proper spacing between the centers of gears in a gear train to a specified tolerance;  (H) apply positional tolerances to assembled parts;  (I) predict the production cost of a product given process information and a bill of materials;  (J) apply the correct spindle speed for a computer-aided manufacturing device by calculation;  (K) apply the correct feed rate for a computer-aided manufacturing device by using calculation;  (L) calculate the pressure drop in an injection mold system;  (M) design a gate size in an injection mold system using the gate width and depth formulas;  (N) determine the size of a mold; and  (O) create size runners for a multi-cavity mold. | |
| **Unit 6: Measuring Electronic Quantities**  In this unit, students will display, explain, or justify mathematical ideas and arguments using precise mathematical language in written or oral communication. The culminating activity will include having students calculate the cost of operating an electric motor. | 15 Periods  675 Minutes | (7) The student calculates electronic quantities and uses electrical measuring instruments to experimentally test their calculations. The student is expected to:  (A) apply common electronic formulas to solve problems;  (B) use engineering notation to properly describe calculated and measured values;  (C) compare and contrast the mathematical differences between a direct current and alternating current;  (D) show the effect and give an application of an inductor in an alternating current circuit;  (E) show the effect and give an application of a capacitor in an alternating current circuit;  (F) create a resistive capacitive timing circuit in a time-delay circuit;  (G) calculate the output voltage and current load of a transformer;  (H) calculate the effective alternating current voltage root mean square given the peak alternating current voltage and the peak alternating current voltage given the root mean square value; and  (I) calculate the cost of operating an electric motor. | |
| **Unit 7: Mathematical Principles of Pneumatic Pressure and Flow**  Students will analyze mathematical relationships to connect and communicate mathematical ideas. Students will display, explain, or justify mathematical ideas and arguments using precise mathematical language in written or oral communication. In this unit, students will complete activities such as calculating the force output of a cylinder in retraction and extension and explaining how gage pressure and absolute pressure are different. The culminating activity will include calculating the effect of impeller diameter and speed on the flow rate of a centrifugal pump and predicting the effect of impeller diameter on a pump head capacity curve. | 15 Periods  675 Minutes | (8) The student applies mathematical principles of pneumatic pressure and flow to explain pressure versus cylinder force, apply and manipulate pneumatic speed control circuits, and describe maintenance of pneumatic equipment, centrifugal pump operation and characteristics, data acquisition systems, pump power, and pump system design. The student is expected to:  (A) calculate the force output of a cylinder in retraction and extension;  (B) explain how gage pressure and absolute pressure are different;  (C) explain the individual gas laws and use the ideal gas law to solve problems;  (D) convert air volumes at pressures to free air volumes;  (E) compare dew point and relative humidity to explain their importance;  (F) explain the importance of the two units of pump flow rate measurement;  (G) convert between mass and volumetric flow rate;  (H) differentiate between unit analysis such as converting units of pressure between English and SI units and dimensional analysis such as Force and Pressure;  (I) convert between units of head and pressure;  (J) explain the importance of total dynamic head in terms of suction and discharge head;  (K) demonstrate the measurement of the total head of a centrifugal pump;  (L) calculate Reynolds number and determine the type of fluid flow in a pipe, including laminar flow, transitional flow, and turbulent flow;  (M) calculate friction head loss in a given pipe length using head loss tables or charts;  (N) calculate total suction lift, total suction head, total discharge head, and the total dynamic head of a system for a given flow rate;  (O) calculate hydraulic power;  (P) calculate centrifugal pump brake horsepower given pump efficiency and hydraulic power;  (Q) calculate the effect of impeller diameter and speed on the flow rate of a centrifugal pump and pump head;  (R) predict the effect of impeller diameter on a pump head capacity curve; and  (S) calculate net positive suction head. | |
| **Unit 8: Mathematical Principles of Material Engineering**  In this unit, students will perform such functions such as calculating stress, strain, and elongation using the modulus of elasticity and calculate shear stress for a material with a given set of data. The culminating activity will include applying factors of safety to material engineering designs; and creating material testing conditions for a model using equipment such as a polariscope. | 15 Periods  675 Minutes | (9) The student applies mathematical principles of material engineering, including tensile strength analysis, data acquisition systems, compression testing and analysis, shear and hardness testing and analysis, and design evaluation. The student is expected to:  (A) calculate stress, strain, and elongation using the modulus of elasticity for a material or model with a given set of data;  (B) analyze and explain the importance of sensitivity in relation to material engineering;  (C) analyze the operation of a data-acquisition application or program;  (D) mathematically analyze a part for stress and strain under a compression load;  (E) calculate shear stress for a material with a given set of data;  (F) use the Brinell hardness number to determine the ultimate tensile strength of a material;  (G) apply factors of safety to material engineering designs; and  (H) create material testing conditions for a model using equipment such as a polariscope. | |
| **Unit 9: Mathematical Principles for Mechanical Drives**  In this unit, students will apply mathematical principles for mechanical drives, including levers, linkages, cams, turnbuckles, pulley systems, gear drives, key fasteners, v-belt drives, and chain drives. The culminating activity will have students compare the advantages and disadvantages of the three classes of levers and calculate the coefficient of friction in its proper units of measurement. | 15 Periods  675 Minutes | (10) The student applies mathematical principles for mechanical drives, including levers, linkages, cams, turnbuckles, pulley systems, gear drives, key fasteners, v-belt drives, and chain drives. The student is expected to:  (A) calculate the weight of an object for a given mass;  (B) analyze and calculate torque for a given application using the proper units of measurement;  (C) calculate the magnitude of force applied to a rotational system;  (D) calculate the mechanical advantage of first-, second-, and third-class levers;  (E) compare the advantages and disadvantages of the three classes of levers for different applications;  (F) calculate and analyze the coefficient of friction in its proper units of measurement. | |
| **Unit 10: Mathematical Principles for Mechanical Drives Part II**  This unit will continue to have students investigate principles for mechanical drives. Culminating activities will have students demonstrate numerous examples of pitch and analyze its proper application, as well as calculate the shaft speed and torque of a belt drive and chain drive system. | 15 Periods  675 Minutes | (10) The student applies mathematical principles for mechanical drives, including levers, linkages, cams, turnbuckles, pulley systems, gear drives, key fasteners, v-belt drives, and chain drives. The student is expected to:  (G) analyze and calculate mechanical advantage for simple machines using proper units of measurement;  (H) calculate the mechanical advantage of gear drive systems;  (I) compare and contrast at least two methods of loading a mechanical drive system;  (J) calculate rotary mechanical power applied to an application;  (K) analyze the mechanical efficiency of a given application;  (L) demonstrate various examples of pitch and analyze its proper application;  (M) calculate the shaft speed and torque of a belt drive and chain drive system; and  (N) calculate sprocket ratio and analyze its importance to various applications. | |
| **Unit 11: Mathematical Principles of Quality Assurance**  In this unit, students will analyze quality assurance control charts, geometric dimensioning and tolerancing, and location, orientation, and form tolerances. The culminating activity will include using a manually constructed histogram to analyze a given set of data and constructing a mean-value-and-range chart to determine if a process remains constant over a specified range of time. | 15 Periods  675 Minutes | (11) The student applies mathematical principles of quality assurance, including using precision measurement tools, statistical process control, control chart operation, analysis of quality assurance control charts, geometric dimensioning and tolerancing, and location, orientation, and form tolerances. The student is expected to:  (A) evaluate the readings of dial calipers and micrometers to make precise measurements;  (B) use at least three measures of central tendency to analyze the quality of a product;  (C) use a manually constructed histogram to analyze a given set of data;  (D) construct and use a mean-value-and-range chart to determine if a process remains constant over a specified range of time;  (E) examine the maximum and minimum limits of a dimension given its tolerance; and  (F) use position tolerance to calculate the location of a hole. | |
| **Unit 12: Employability Skills**  This unit offers students basic technical skills necessary to fulfill careers in the workforce. Through group activities, students will demonstrate interpersonal skills, such as: communication, professionalism, decision-making, leadership, and conflict resolution. The unit culminates with a peer review evaluation and reflection upon skills needed for success in the workforce. | 10 Periods  450 Minutes | (1) The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:  (A) demonstrate knowledge of how to dress appropriately, speak politely, and conduct oneself in a manner appropriate for the profession;  (B) show the ability to cooperate, contribute, and collaborate as a member of a group in an effort to achieve a positive collective outcome;  (C) present written and oral communication in a clear, concise, and effective manner;  (D) demonstrate time-management skills in prioritizing tasks, following schedules, and performing goal-relevant activities in a way that produces efficient results; and  (E) demonstrate punctuality, dependability, reliability, and responsibility in performing assigned tasks as directed. | |