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**Bellmore Merrick Central High School District**

Calhoun High School, Kennedy High School, Mepham High School

**Principles of Engineering**

**Course Description:**

Grade 11: Principles of Engineering is a broad-based survey course that will help student explore and understand the fields of engineering and engineering technology, as well as other high-tech career possibilities. Students will expand upon the problem-solving skills gained in Foundations of Engineering to create solutions to engineering challenges. They will investigate various engineering systems and manufacturing processes. This project-based course will enable students to experience engineering through theory and hands-on problem-solving activities.

**Pre/Co-Requisite**: Foundations of Engineering, Chemistry, Algebra 2/Trigonometry.

**Textbook**: Principles of Engineering; 1st Edition Handley, Coon, Marshall

**Class Hours**: Daily 40 Minute Periods, 180 Days, 120 Hours

**Instructors:** D. Ocampo, A. Greaves, C. Celeste, M. Kramer

**Grading Breakdown:**

**Quarter Average:**

Tests - 50%

Projects - 40%

Assignments - 10%

**Final Average:**

Quarter 1 - 20%

Quarter 2 - 20%

Midterm - 4%

Quarter 3 - 20%

Quarter 4 - 20%

Final - 16%

**Course Learning Objectives:**

* Students will be able to demonstrate knowledge of mathematics, science, and engineering
* Students will be able to design and conduct experiments, as well as analyze and interpret data
* Students will be able to design a system, component, or process to meet desired needs within real-world constraints.
* Students will have an ability to identify, formulate, and solve engineering problems.

**Principles of Engineering curriculum outline**

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| **Week** | **Topic** |
| **1 - 6** | **Circuits: Introduction to Circuits and Breadboarding**   * General Safety in the Engineering Classroom * Scientific and Engineering Notation * Investigating Basic Circuits * Investigating Combinational Circuits * Introduction to Breadboarding * Introduction to Mesh and Nodal Analysis * Using multiple voltage sources * **Unit Capstone Project - Analyze difference in voltage and current in series, parallel and combinational circuits using breadboards**   + breadboards   + multimeters * Exam |
| **6 - 8** | **Circuits: Analyzing RC Circuits**   * Introduction to Capacitance * Solving RC circuits * **Unit Capstone Project - Investigate differences in voltage and current in RC circuits when changing the capacitance and resistance combinations.**   + breadboards   + multimeters   + capacitors   + resistors * Exam |
| **9 - 11** | **Circuits: AC vs DC current**   * Introduction to AC current * Investigate different types of generators * **Unit Capstone Project - Creating a simple AC electric generator** * Exam |
| **12 - 18** | **Hydraulics and Pneumatics:**   * Introduction to Fluid Power * Pascal’s Law * Introduction to Hydraulics * Fluid flow velocity * Mechanical Advantage in a Hydraulic system * Bernoulli’s Principle * Viscosity * **Topic Capstone Project - Hydraulic lift** * Introduction to Pneumatics * Pneumatics vs Hydraulics * Absolute Pressure vs Gauge pressure * Perfect Gas Laws * **Topic Capstone Project - Pneumatic Braking System** * Exam |
| **18 - 22** | **Thermodynamics**   * Temperature and Thermodynamic Equilibrium * 1st and 2nd Laws of Thermodynamics * Calculating Thermal Energy Transfer * Calculating Thermal Resistance and Thermal Conductance of a material * Stefan’s Law * **Unit Capstone Project - design and create an insulated box and calculate various factors such as thermal resistance, total energy loss in an amount of time and the rate of energy loss.** * Exam |
| **22 - 25** | **Stress and Strain**   * Introduction to Materials and Material Testing * Tensile stress and strain of samples * **Topic Capstone Project - students will identify and calculate test sample material properties using a stress strain curve after observing differences in material strength using a Structural Stress Analyzer (SSA).** * Introduction to axial and shear deflection. * Exam |
| **25 - 26** | **Statics: Centroids**   * Introduction to Centroids * **Topic Capstone Project - determine the centroid location for various engineering shapes and test them** * Exam |
| **26 - 27** | **Statics: Beam Deflection**   * Introduction to Beam Deflection * Calculating moment of inertia and modulus of elasticity * **Topic Capstone Lab - investigating the factors that affect beam deflection such as loads, moment of inertia and length of the beam.** * Exam |
| **28 - 33** | **Statics: Truss Forces**   * Introduction to Free Body Diagrams * Calculating external truss forces * Calculating internal truss forces * **Topic Capstone Project - design, build, test and analyze a truss bridge.** * Exam |
| **34 - 36** | **Programming**   * Review of programming for fischertechnik or VEX platforms * **Capstone Project - design, build, and program an autonomous vehicle that performs a task, such as following a black line.** |

**Topic–specific outlines, performance objectives, and assessment targets.**

**Circuits**

**Concepts**

* Electricity requires the understanding of the three fundamental concepts of voltage, current, and resistance.
* Mesh analysis and Nodal Analysis, multiple voltage sources and breaking down combinational circuits.
* RC circuits.
* Inner workings of breadboarding.

**Performance Objectives**

* Calculate voltage, current and resistance in simple series and parallel circuits to review from previous years.
* Calculate voltage, current and resistance in combinational circuits using mesh and nodal analysis and multiple voltage sources.
* Calculate resistance and capacitance in RC circuits.
* Perform hands on laboratory experiences using breadboards.

**Assessment**

* Demonstrate knowledge of combinational and RC circuits, mesh and nodal analysis and multiple voltage sources.
* Apply knowledge of circuits to breadboarding projects.

**Hydraulics and Pneumatics**

**Concepts**

* Fluid power systems are categorized as either pneumatic, which utilizes gas, or hydraulic, which utilizes liquid.
* Fluid power is possible because in a system of confined fluid, pressure acts equally in all directions.
* The most basic components of all fluid power systems include a reservoir or receiver, a pump or compressor, a valve, and a cylinder.
* Fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.
* The laws which describe the behavior of fluid systems
* The standard conventions for calculating values within fluid systems aid in the design and understanding of such systems.
* Standard schematic symbols and conventions are used to communicate fluid power designs.

**Performance Objectives**

* Explain the difference between pneumatic and hydraulic systems.
* Explain the basic components in a fluid power system.
* Design and create a pneumatic system.
* Design and create a hydraulic system.
* Calculate pressure, temperature, volume and force.

**Assessment**

* Demonstrate knowledge of pneumatic and hydraulic systems calculating pressure, temperature volume and pressure.

**Thermodynamics**

**Concepts**

* Thermodynamics is the study of the effects of work, thermal energy, and energy on a system.
* Thermal energy can transfer via convection, conduction, or radiation.

**Performance Objectives:**

* Explain the importance of R-value related to insulation material.
* Explain the relationship between thermodynamics and system efficiency.
* Apply their understanding of thermodynamics to the R-value, thermal transfer, and conduction calculations.
* Test and apply the relationship between R-values and recyclable insulation.
* Calculations for conduction, R-values, and radiation.
* Apply electrical energy transfer and production to applications involving mechanical work.
* Identify and discuss ways to maximize energy efficiency to limitation of thermal energy transfer.

**Assessment**

* Explain the 1st and 2nd law of thermodynamics
* Explain the difference between conduction, convection and radiation.
* Perform calculations using thermal energy transfer equations including thermal resistivity, thermal conductivity, and Stefan’s Law.

**Statics**

**Concepts**

* Laws of motion describe the interaction of forces acting on a body.
* Structural member properties including centroid location, moment of inertia, and modulus of elasticity are important considerations for structure design.
* Static equilibrium occurs when the sum of all forces acting on a body are equal to zero.
* Applied forces are vector quantities with a defined magnitude, direction, and sense, and can be broken into vector components.
* Forces acting at a distance from an axis or point attempt or cause an object to rotate.
* In a statically determinate truss, translational and rotational equilibrium equations can be used to calculate external and internal forces.
* Free body diagrams are used to illustrate and calculate forces acting upon a given body.

**Performance Objectives**

* Create free body diagrams of objects, identifying all forces acting on the object.
* Mathematically locate the centroid of structural members.
* Calculate moment of inertia of structural members.
* Differentiate between scalar and vector quantities.
* Identify magnitude, direction, and sense of a vector.
* Calculate the X and Y components given a vector.
* Calculate moment forces given a specified axis.
* Use equations of equilibrium to calculate unknown forces.
* Use the method of joints strategy to determine forces in the members of a statically determinate truss.

**Assessment**

* Explain the importance of free body diagrams
* Explain how loads are transmitted through a structure.
* Explain how to calculate internal and external reaction forces relating to a structure.
* Apply their knowledge of statics to calculate the internal and external forces acting on a system.
* Create a truss system to withstand design requirements.
* Reflect on what they would have done differently if the truss design project were to be repeated.

**Programming / CAD**

**Concepts**

* Flowcharts provide a step by step schematic representation of an algorithm or process.
* Use of CAD (*Autodesk Inventor*) to design a prototype.

**Performance Objectives**

* Design, build and program an autonomous vehicle that performs a task, such as, following a black line.
* Prepare a design brief along with sketches and annotations for their design.
* Build, test and revise and redesign their projects.
* Use *Autodesk Inventor* and a 3D printer to create a part that they will need on their vehicles.
* Program their vehicles to drive autonomously.

**Assessment**

* Students will be assessed on their final design, design brief, *Autodesk Inventor* files and the use and necessity of the part which was 3D printed.

**Beam Deflection**

**Concepts**

* When a beam is subjected to a load it will deflect.
* The location of the centroid, with respect to the x-axis, is a factor which determines the deflection on a beam.
* The material of a beam is a factor which determines deflection of the beam.
* Loads can be concentrated or distributed.

**Performance Objectives:**

* Calculate moment forces given a specified axis.
* Calculate the Moment of Inertial of structural members.
* Determine deflection of a beam under concentrated loads and distributed loads.

**Assessment:**

* Explain how the Moment of Inertia affects beam deflection.
* Explain how the Modulus of Elasticity relates to beam deflection.
* Explain how the Length of the beam affects it’s deflection.
* Explain how to calculate deflection of beams under various loading conditions.

**Material Testing**

**Concepts:**

* Engineers utilize a design process and mathematical formulas to solve and document design problems.
* Material testing aids in determining a product’s reliability, safety, and predictability in function.
* Engineers perform destructive and non-destructive tests on material specimens for the purpose of identifying and verifying the properties of various materials.
* Material testing provides a reproducible evaluation of material properties.
* Tensile testing data is used to create a test sample stress strain curve.
* Strain data points are used to identify and calculate sample material properties including elastic range, proportional limit, modulus of elasticity, elastic limit, resilience, yield point, plastic deformation, ultimate strength, failure, and ductility.

**Performance Objectives:**

* Solve word problems involving stress/strain.
* Obtain measurements of test samples.
* Obtain test data from a tensile test machine.
* Identity and calculate test sample material properties using stress strain curves.

**Assessment:**

* Explain the importance of material testing as a verification process.
* Tensile test a material sample and identify and calculate material properties.
* Write journal entries reflecting on their learning and experiences. An example writing prompt: What is something you learned today about material testing, manufacturing processes, or engineering problem solving that you did not understand or know before?
* Reflect on their work by recording their thoughts and ideas in journals. They may use self-assessments as a basis for revision and improvement.