Multiple Category Scope and Sequence: Scope and Sequence Report For Course Standards and Objectives, Content, Skills, Vocabulary

Wednesday, August 20, 2014, 3:14PM

	Unit	Course Standards and Objectives	Content	Skills	Vocabulary
District Intermediate **Introduction to Engineering Deisgn (21.0113) (District)** 2014-2015 **Collaboration**	**Unit 1, Design Process** (Week 1, 2 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.01 OVERVIEW ▪ Objective 210120.0109 Students will explore career opportunities in a given engineering field and list the educational requirements for each profession. (Education Requirements) Standart 210120.02 INTRODUCTION TO DESIGN ▪ Objective 210120.0201 Students will list the seven steps of the design process and explain the activities that occur during each phase. (Design Process) ▪ Objective 210120.0202 Students will assess the value of working as a team and understand the benefits of collaboration. (Design Process) ▪ Objective 210120.0203 Students will realize the importance of focusing on detail	**Understanding, Knowledge** ▪ An engineering design process involves a characteristic set of practices and steps. Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem. A problem and the requirements for a successful solution to the problem should be clearly communicated and justified. Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time. A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints. Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution. Problem solutions are optimized through evaluation and reflection and should be clearly communicated. The scientific method guides the testing and evaluation of prototypes of a problem solution. Geometric shapes and forms are	▪ Identify and define the terminology used in engineering design and development. ▪ Identify the steps in an engineering design process and summarize the activities involved in each step of the process. ▪ Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. ▪ Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief. ▪ Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders. ▪ Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. ▪ Write a design brief to communicate the problem, problem constraints, and solution criteria. ▪ Generate and document multiple ideas or solution paths to a problem through brainstorming. ▪ Construct a testable prototype of a problem solution. ▪ Describe the design process used in the solution of a particular problem and reflect on all steps of the design process. ▪ Justify and validate a problem solution. ▪ Identify limitations in the design process and the problem solution and recommend possible improvements or caveats. ▪ Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements. ▪ Explain the concept of proportion and how it relates to freehand sketching. ▪ Generate non-technical concept sketches to represent objects or convey design	**Key Term** **Assess** **Assessment** **Brainstorm** **Client** **Creativity** **Criteria** **Constraint** **Design** **Design Brief** **Design Process** **Design Statement** **Designer** **Engineer** **Engineering Notebook** **Innovation** **Invention** **Iterative**

when executing the design process. (Design Process)

- Objective 210120.0204 Students will apply the steps of the design process to solve a variety of design problems. (Design Process)
- Objective 210120.0207 Students will express their understanding of the principles and elements of design by incorporating them in design solutions. (Principles and Elements of Design)

Standard 210120.03 STUDENT PORTFOLIO DEVELOPMENT

- Objective 210120.0301 Students will identify the proper elements of a fully developed portfolio. (Student Portfolio Development)
- Objective 210120.0303 Students will compare and contrast defined elements of a good portfolio specified in the PowerPoint presentation to the sample provided in the PLTW . Design Resource Guide. (Student Portfolio Development)
- Objective 210120.0304 Students will develop a portfolio to organize and display evidence of their work. (Student

described and differentiated by their characteristic features.

Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.

Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.

Specific oral communication techniques are used to effectively convey information and communicate with an audience.

Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.

Engineering has a global impact on society and the environment.

Engineering consists of a variety of specialist sub-fields, with each contributing in different ways to the design and development of solutions to different types of problems.

In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.

ideas.

- Create drawings or diagrams as representations of objects, ideas, events, or systems.
- Select and utilize technology (software and hardware) to create high impact visual aids.
- Use presentation software effectively to support oral presentations.
- Define and differentiate invention and innovation.
- Assess the development of an engineered product and discuss its impact on society and the environment.
- Identify and discuss a Grand Challenge for Engineering (as identified by the National Academy of Engineering) and its potential impact on society and the environment.
- Identify and differentiate between mechanical, electrical, civil, and chemical engineering fields.
- Describe the contributions of engineers from different engineering fields in the design and development of a product, system, or technology.
- Differentiate between the work of an engineer and the work of a scientist.
- Demonstrate positive team behaviors and contribute to a positive team dynamic.

Piling-on

Problem Identification

Product

Prototype

Research

	Portfolio Development)				
Unit 2, Technical Sketching and Drawing (Week 3, 4 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.04 SKETCHING AND VISUALIZATION ▪ Objective 210120.0401 Students will integrate proper sketching techniques and styles in the creation of sketches. (Sketching Techniques) ▪ Objective 210120.0402 Students will demonstrate the ability to produce two-dimensional geometric figures. (Sketching Techniques) ▪ Objective 210120.0404 Students will formulate pictorial sketches to develop ideas, solve problems, and understand relationships during the design process. (Pictorial Sketching) ▪ Objective 210120.0409 Students will interpret annotated sketches in the design analysis process. (Annotated Sketches) ▪ Objective 210120.0411 Students will develop properly annotated sketches to accurately convey data in a design solution.	**Understandings, Knowledge** Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time. Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other. Geometric shapes and forms are described and differentiated by their characteristic features. ▪ The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic. ▪ Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing. ▪ Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.	▪ Generate and document multiple ideas or solution paths to a problem through brainstorming. ▪ Identify flat patterns (nets) that fold into geometric solid forms. ▪ Explain the concept of proportion and how it relates to freehand sketching. ▪ Identify and define technical drawing representations including isometric, orthographic projection, oblique, perspective, auxiliary, and section views. ▪ Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views. ▪ Identify line types (including construction lines, object lines, hidden lines, cutting plane lines, section lines, and center lines) used on a technical drawing per ANSI Line Conventions and Lettering Y14.2M-2008 and explain the purpose of each line. ▪ Determine the minimum number and types of views necessary to fully detail a part. ▪ Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. ▪ Apply tonal shading to enhance the appearance of a pictorial sketch and create a more realistic appearance of a sketched object ▪ Hand sketch 1-point and 2-point perspective pictorial views of a simple object or part given the object, a detailed verbal description or the object, a pictorial view of the object, and/or a set of orthographic projections. ▪ Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. ▪ Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object. ▪ Hand sketching of multiple representations to fully and accurately detail simple objects	**Cabinet Pictorial** **Cavalier Pictorial** **Center Line** **Construction Line** **Depth** **Dimension** **Dimension Line** **Documentation** **Drawing** **Edge** **Ellipse** **Extension Line** **Freehand** **Grid** **Height** **Hidden Line** **Isometric Sketch** **Leader Line** **Line** **Line Conventions**

(Annotated Sketches)

Standard 210120.05
GEOMETRIC RELATIONSHIPS

- Objective 210120.0502 Students will identify major geometric shapes (isosceles triangle, right triangle, scalene triangle, rectangles, squares, rhombus, trapezoid, pentagon, hexagon, and octagon). (Forms and Shapes)

or parts of objects is a technique used to convey visual and technical information about an object.

- Create drawings or diagrams as representations of objects, ideas, events, or systems.

Line Weight

Long-Break Line

Manufacture

Measurement

Multi-View Drawing

Object Line

Oblique Sketch

Orthographic Projection

Perspective Sketch

Pictorial Sketch

Plane

Point

Profile

Projection Line

Projection Plane

Proportion

Scale

Section Lines

Shading

Short-Break Line

Shape

Unit 3, Measurent Statistics
(Week 7, 5 Weeks)

UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design"

Standard 210120.01 OVERVIEW

- Objective 210120.0106 Students will review the history of measurement tools and identify two innovations that have led to improved functionality of that tool. (History of Design)
- Objective 210120.0107 Students will explore a given professional organization and summarize in a short PowerPoint presentation the range of services provided by the organization . (Professional Organizations)
- Objective 210120.0203 Students will realize the importance of focusing on detail when executing the design process. (Design Process)

Standard 210120.03 STUDENT PORTFOLIO DEVELOPMENT

- Objective 210120.0304 Students will develop a portfolio to organize and display evidence

- An engineering design process involves a characteristic set of practices and steps.
- Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.
- Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.
- Problem solutions are optimized through evaluation and reflection and should be clearly communicated.
- The scientific method guides the testing and evaluation of prototypes of a problem solution.
- Statistical analysis of uni-variate data facilitates understanding and interpretation of numerical data and can be used to inform, justify, and validate a design or process.
- Spreadsheet programs can be used to store, manipulate, represent, and analyze data.
- Units and quantitative reasoning can guide mathematical manipulation and the solution of problems involving quantities.
- Error is unavoidable when measuring physical properties, and a measurement is characterized by the precision and accuracy of the measurement.
- The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic.
- Technical drawings convey information according to an established set of drawing

Knowledge and Skills

- Identify and define the terminology used in engineering design and development.
- Identify the steps in an engineering design process and summarize the activities involved in each step of the process.
- Complete a design project utilizing all steps of a design process and find a solution that meets specific design requirements.
- Generate and document multiple ideas or solution paths to a problem through brainstorming.
- Construct a testable prototype of a problem solution.
- Describe the design process used in the solution of a particular problem and reflect on all steps of the design process.
- Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
- Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
- Calculate statistics related to central tendency including mean, median, and mode.
- Represent data with plots on the real number line (e.g., dot plots, histograms, and box plots).
- Use statistics to quantify information, support design decisions, and justify problem solutions.
- Calculate statistics related to variation of data including (sample and population) standard deviation and range.
- Distinguish between sample statistics and population statistics and know appropriate applications of each.
- Use the Empirical Rule to interpret data

Sketch

Solid

Key Term

Accuracy

Arrowheads

Caliper

Class Interval

Convert

Data

Data Set

Dimension

Dimension Lines

Dot Plot

Frequency

Graph

Histogram

International Organization for Standardization (ISO)

International System of Units (SI)

Line Plot

Mean

of their work. (Student Portfolio Development)

Standard 210120.04
SKETCHING AND VISUALIZATION

- Objective 210120.0411 Students will develop properly annotated sketches to accurately convey data in a design solution. (Annotated Sketches)

Standard 210120.08
MODELING ANALYSIS AND VERIFICATION

- Objective 210120.0802 Students will evaluate the accuracy of mass properties calculations. (Mass Properties)
- Objective 210120.0805 Students will interpret and use correct tolerancing techniques when dimensioning solid models. (Tolerancing)
- Objective 210120.0806 Students will understand and solve tolerance problems, including limits and fits. (Tolerancing)
- Objective 210120.0807 Students will understand the differences between clearance fit, interference fit, and allowance.

practices which allow for detailed and universal interpretation of the drawing.

- Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.
- Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.
- Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.
- Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.
- In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.

and identify ranges of data that include 68 percent of the data, 95 percent of the data and 99.7 percent of the data.

- Use a spreadsheet program to store and manipulate raw data.
- Use a spreadsheet program to perform calculations using formulas.
- Use a spreadsheet program to create and display a histogram to represent a set of data.
- Use function tools within a spreadsheet program to calculate statistics for a set of data including mean, median, mode, quartiles, range, and standard deviation.

- Use units to guide the solution to multi-step problems through dimensional analysis and choose and interpret units consistently in formulas.
- Choose a level of precision and accuracy appropriate to limitations on measurement when reporting quantities.
- Convert quantities between units in the SI and the US Customary measurement systems.
- Convert between different units within the same measurement system including the SI and US Customary measurement systems.

- Define accuracy and precision in measurement.
- Evaluate and compare the accuracy and precision of different measuring devices.
- Measure linear distances (including length, inside diameter, and hole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision.

- Identify and define technical drawing representations including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.

- Determine the minimum number and types of views necessary to fully detail a part.
- Identify and correct errors and omissions in technical drawings including the line work,

Measure

Median

Mode

Normal Distribution

Numeric Constraint

Precision

Scale

Scatter Plot

Significant Digits

Standard Deviation

Statistics

Unit

US Customary Measurement System

Variation

	(Tolerancing)	view selection, view orientation, appropriate scale, and annotations. ▪ Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. ▪ Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. ▪ Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules. ▪ Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. ▪ Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial and isometric view of the object. ▪ Generate non-technical concept sketches to represent objects or convey design ideas. ▪ Organize and express thoughts and information in a clear and concise manner. ▪ Adjust voice and writing style to align with audience and purpose. ▪ Support design ideas using a variety of convincing evidence. ▪ Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design. ▪ Create drawings or diagrams as representations of objects, ideas, events, or systems. ▪ Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit 4: Modeling Skills (Week 12, 8 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.03 STUDENT PORTFOLIO DEVELOPMENT ▪ Objective 210120.0301 Students will identify the proper elements of a fully developed portfolio. (Student Portfolio Development) ▪ Objective 210120.0302 Students will identify and discuss the ethical issues surrounding portfolio artifacts. (Student Portfolio Development) ▪ Objective 210120.0303 Students will compare and contrast defined elements of a good portfolio specified in the PowerPoint presentation to the sample provided in the PLTW . Design Resource Guide. (Student Portfolio Development) ▪ Objective 210120.0304 Students will develop a portfolio to organize and display evidence of their work. (Student Portfolio Development) Standard 210120.05 GEOMETRIC RELATIONSHIPS ▪ Objective 210120.0508	▪ An engineering design process involves a characteristic set of practices and steps. ▪ Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time. ▪ A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints. ▪ Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution. ▪ Problem solutions are optimized through evaluation and reflection and should be clearly communicated. ▪ The scientific method guides the testing and evaluation of prototypes of a problem solution. ▪ Statistical analysis of uni-variate data facilitates understanding and interpretation of numerical data and can be used to inform, justify, and validate a design or process. ▪ Spreadsheet programs can be used to store, manipulate, represent, and analyze data. ▪ An equation is a statement of equality between two quantities that can be used to describe real phenomenon and solve problems. Solving mathematical equations and inequalities involves a logical process of reasoning and can be accomplished using a variety of strategies and technological tools. Functions describe a special relationship between two sets of data and can be used to represent real world relationships	▪ Identify and define the terminology used in engineering design and development. ▪ Identify the steps in an engineering design process and summarize the activities involved in each step of the process. ▪ Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. ▪ Describe a variety of brainstorming techniques and rules for brainstorming. ▪ Generate and document multiple ideas or solution paths to a problem through brainstorming. ▪ Clearly justify and validate a selected solution path. ▪ Construct a testable prototype of a problem solution. ▪ Describe the design process used in the solution of a particular problem andreflect on all steps of the design process. ▪ Justify and validate a problem solution. ▪ Identify limitations in the design process and the problem solution and recommend possible improvements or caveats. ▪ Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements. ▪ Calculate statistics related to central tendency including mean, median, and mode. ▪ Use statistics to quantify information, support design decisions, and justify problem solutions. ▪ Calculate statistics related to variation of data including standard deviation, interquartile range, and range. ▪ Use a spreadsheet program to store and manipulate raw data. ▪ Use a spreadsheet program to graph bi-variate data and determine an appropriate mathematical model using regression	**Annotate** **Assembly** **Assembly Drawing** **Cartesian Coordinate System** **Component** **Computer-Aided Design or Computer-Aided Drafting (CAD)** **Degree of Freedom** **Design Brief** **Design Statement** **Domain** **Extrusion** **Function** **Geometric Constraint** **Marketing** **Mathematical Modeling** **Mock-up** **Model** **Origin**

Students will distinguish and define geometric constraints. (Geometric Constraints)

- Objective 210120.0509 Students will identify the following geometric constraints in given three-dimensional models: horizontal, vertical, parallel, perpendicular, tangent, concentric, collinear, coincident, and equal. (Geometric Constraints)
- Objective 210120.0511 Students will apply a combination of absolute, relative, and polar coordinates to construct a three-dimensional model. (Coordinate Systems)
- Objective 210120.0512 Students will define the origin planes in the Cartesian Coordinate System. (Coordinate Systems.)

and to solve problems.

Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.

Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.

Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.

Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.

Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.

Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.

analysis.

- Use function tools within a spreadsheet program to calculate statistics for a set of data including mean, median, mode, quartiles, range, **interquatile range,** and standard deviation.

Note: Interquatile range is included for continuous improvement beyond 2013-2014.

- Represent constraints with equations or inequalities.
- Formulate equations and inequalities to represent linear**, quadratic, simple rational and exponential** relationships between quantities.

Note: Quadratic, simple rational, and exponential are included for continuous improvement beyond 2013-2014.

- Compute (using technology) and interpret the correlation coefficient of a linear fit.
- Construct a scatter plot to display bi-variate data, investigate patterns of association, and represent the association with a mathematical model (linear equation) when appropriate.

- Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations.

- Explain the term “function” and identify the set of inputs for the function as the domain and the set of outputs from the function as the range.
- Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.
- Build a function that describes a relationship between two quantities given a graph, a description of a relationship, or two input-output pairs.
- Interpret a function to solve problems in the context of the data.
- Interpret the slope (rate of change) and the intercept (constant term) of a linear

Packaging

Pattern

Physical Model

Plane

Portfolio

Prototype

Range

Revolution

Rotation

Round

Scale Model

Scoring

Solid

Solid Modeling

Subassembly

Translation

Working Drawings

function in the context of data.

- Identify line types (including construction lines, object lines, hidden lines, cutting plane lines, section lines, and center lines) used on a technical drawing per ANSI Line Conventions and Lettering Y14.2M-2008 and explain the purpose of each line.
- Determine the minimum number and types of views necessary to fully detail a part.
- Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.
- Identify and correct errors and omissions in technical drawings including the line work, view selection, view orientation, appropriate scale, and annotations.
- Create a set of working drawings to detail a design project.
- Fabricate a simple object from technical drawings that may include an isometric view, orthographic projections, and a section view.

- Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices.
- Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules.

- Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections.
- Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial view of the object.

- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints.
- Compare the efficiency of the modeling method of an object using different

			combinations of additive and subtractive methods. ▪ Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. ▪ Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. ▪ Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts. ▪ Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement. ▪ Organize and express thoughts and information in a clear and concise manner. ▪ Adjust voice and writing style to align with audience and purpose. ▪ Support design ideas using a variety of convincing evidence. ▪ Utilize project portfolios to present and justify design projects. ▪ Create drawings or diagrams as representations of objects, ideas, events, or systems.	
Unit 5: Geometry of Design (Week 20, 2 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.01 OVERVIEW	▪ An engineering design process involves a characteristic set of practices and steps. ▪ A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.	▪ Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. ▪ Define and justify a design problem, and express the concerns, needs, and desires	**Acute Triangle** **Angle** **Area**

- Objective 210120.0204 Students will apply the steps of the design process to solve a variety of design problems. (Design Process)

Standard 210120.05
GEOMETRIC RELATIONSHIPS

- Objective 210120.0502 Students will identify major geometric shapes (isosceles triangle, right triangle, scalene triangle, rectangles, squares, rhombus, trapezoid, pentagon, hexagon, and octagon). (Forms and Shapes)
- Objective 210120.0504 Students will define the elements and types of angles. (Forms and Shapes)
- Objective 210120.0508 Students will distinguish and define geometric constraints. (Geometric Constraints)
- Objective 210120.0509 Students will identify the following geometric constraints in given three-dimensional models: horizontal, vertical, parallel, perpendicular, tangent, concentric, collinear, coincident, and equal. (Geometric Constraints)
- Objective

- Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.
- Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.
- Problem solutions are optimized through evaluation and reflection and should be clearly communicated.
- The scientific method guides the testing and evaluation of prototypes of a problem solution.
- Spreadsheet programs can be used to store, manipulate, represent, and analyze data.
- An equation is a statement of equality between two quantities that can be used to describe real phenomenon and solve problems.
- Solving mathematical equations and inequalities involves a logical process of reasoning and can be accomplished using a variety of strategies and technological tools.
- Units and quantitative reasoning can guide mathematical manipulation and the solution of problems involving quantities.

Error is unavoidable when measuring a physical property and a measurement is characterized by the precision and accuracy of the measurement.

Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other.

Physical properties of objects are used to describe and model objects and can be used to define design requirements, as a means to compare potential solutions to a

of the primary stakeholders.

- Generate and document multiple ideas or solution paths to a problem through brainstorming.
- Construct a testable prototype of a problem solution.
- Identify limitations in the design process and the problem solution and recommend possible improvements or caveats.
- Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
- Use a spreadsheet program to store and manipulate raw data.
- Use a spreadsheet program to graph bi-variate data and determine an appropriate mathematical model using regression analysis.
- Use function tools within a spreadsheet program to calculate statistics for a set of data including mean, median, mode, quartiles, range, and standard deviation.
- Construct a scatter plot to display bi-variate data, investigate patterns of association, and represent the association with a mathematical model (linear equation) when appropriate.
- Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations.
- Convert quantities between units in the SI and the US Customary measurement systems.
- Convert between different units within the same measurement system including the SI and US Customary measurement systems.
- Measure linear distances (including length, inside diameter, and hole depth) with

Axis

Center of Gravity

Centroid

Circle

Circumscribe

Cylinder

Density

Diameter

Ellipse

Fillet

Inscribe

Mass

Meniscus

Obtuse Triangle

Parallelogram

Pi (π)

Polygon

Principal Axes

Prism

Quadrilateral

Radius

Rectangle

- 210120.0510 Students will apply the right hand rule to identify the X, Y, and Z axes of the Cartesian Coordinate System. (Coordinate Systems)
- Objective 210120.0511 Students will apply a combination of absolute, relative, and polar coordinates to construct a three-dimensional model. (Coordinate Systems)
- Objective 210120.0512 Students will define the origin planes in the Cartesian Coordinate System. (Coordinate Systems.)
- Objective 210120.0513 Students will identify the origin and planar orientations of each side of a three-dimensional model. (Coordinate Systems)

Standard 210120.06 MODELING

- Objective 210120.0613 Students will interpret a sketch and generate a model using a computer and a CAD software package. (Computer Modeling)
- Objective 210120.0615 Students will draw a two-dimensional sketch using a CAD package. (Computer Modeling)
- Objective 210120.0616

problem, and as a tool to specify final solutions.

Functions describe a special relationship between two sets of data and can be used to represent real world relationships and to solve problems.

Geometric shapes and forms are described and differentiated by their characteristic features.

Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.

Computer aided drafting and design (CAD) software packages allow virtual testing and analysis of designs using 3D models, assemblies, and animations.

In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.

accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision.
- Measure mass with accuracy using a scale and report the measurement using an appropriate level of precision.
- Measure volume with accuracy and report the measurement with an appropriate level of precision.

- Identify three dimensional objects generated by rotations of two-dimensional shapes and vice-versa.

- Define the term “physical property” and identify the properties of length, volume, mass, density, surface area, centroid, principle axes, and center of gravity as physical properties.
- Solve volume problems using volume formulas for rectangular solids, cylinders, pyramids, cones, and spheres.
- Solve real world and mathematical problems involving area and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, right prisms, cylinders, and spheres.
- Calculate a physical property indirectly using available data or perform appropriate measurements to gather the necessary data (e.g., determine area or volume using linear measurements or determine density using mass and volume measurements).
- Use physical properties to solve design problems (e.g., design an object or structure to satisfy physical constraints or minimize cost).

- Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.
- Interpret the slope (rate of change) and the intercept (constant term) of a linear function in the context of data.

- Identify types of polygons including a square, rectangle, pentagon, hexagon, and octagon.
- Identify and differentiate geometric

Regular Polygon

Right Triangle

Round

Square

Surface Area

Tangent

Title Block

Triangle

Vertex

Volume

Quadrilateral

	Students will apply geometrical and dimensional constraints to a sketch. (Computer Modeling) ▪ Objective 210120.0617 Students will demonstrate the ability to generate a three-dimensional model. (Computer Modeling) ▪ Objective 210120.0618 Students will understand and demonstrate the use of work features and how they are applied while constructing a solid model. (Computer Modeling) ▪ Objective 210120.0619 Students will recognize the use and need of work planes, axes, and points in the development of a computer model. (Computer Modeling) ▪ Objective 210120.0620 Students will demonstrate the ability to modify a sketch or feature of a model. (Computer Modeling)		constructions and constraints such as horizontal lines, vertical lines, parallel lines, perpendicular lines, colinear points, tangent lines, tangent circles, and concentric circles. ▪ Identify types of angles including an acute angle, obtuse angle, straight angle, and right angle. ▪ Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. ▪ Assign a specific material (included in the software library) to a part and use the capabilities of the CAD software to determine the mass, volume, and surface area of an object for which a 3D solid model has been created. ▪ Assign a density value to a new material (not included in the software library) and apply the material to a 3D solid model within CAD software in order to determine the physical properties of the object. ▪ Demonstrate positive team behaviors and contribute to a positive team dynamic.	
Unit 6: Reverse Engineering (Week 22, 4 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.01 OVERVIEW ▪ Objective 210120.0205 Students will investigate the	▪ Material and fastener choices used in a product design should be carefully chosen based on the impact to the product's design, cost, performance, marketability, environmental impact, and expected service life. ▪ Error is unavoidable when measuring a physical property and a measurement is characterized by the precision and accuracy of the	▪ Evaluate and compare multiple materials and fastener choices for a product design based on the impact on the design's cost, performance, marketability, environmental impact, and expected service life. ▪ Measure linear distances (including length, inside diameter, and hole depth) with accuracy using a scale, ruler, or dial caliper and report the measurement using an appropriate level of precision. ▪ Measure mass with accuracy using a scale	**Aesthetic** **Asymmetry** **Balance** **Color** **Contrast**

principles and elements of design and demonstrate their use in the design process incorporating them in design solutions. (Principles and Elements of Design)

- Objective 210120.0206 Students will identify the use of the principles and elements of design in various products, print media, and art forms. (Principles and Elements of Design)
- Objective 210120.0207 Students will express their understanding of the principles and elements of design by incorporating them in design solutions. (Principles and Elements of Design)
- Objective 210120.0208 Students will collect and display examples of the application of the principles and elements of design utilized in products, print media, and art forms. (Principles and Elements of Design)

measurement.

- Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.
- Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.
- Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.
- Computer aided drafting and design (CAD) software packages allow virtual testing and analysis of designs using 3D models, assemblies, and animations.
- Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.
- Specific oral communication techniques are used to effectively convey information and communicate with an audience.
- Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.
- Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object

and report the measurement using an appropriate level of precision.

- Determine the minimum number and types of views necessary to fully detail a part.
- Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.

- Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections.
- Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.

- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints.
- Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice.

- Assign a specific material (included in the software library) to a part and use the capabilities of the CAD software to determine the mass, volume, and surface area of an object for which a 3D solid model has been created.

- Organize and express thoughts and information in a clear and concise manner.
- Adjust voice and writing style to align with audience and purpose.
- Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and

Element

Emphasis

Form

Gestalt

Graphic Design

Harmony

Message Analysis

Pattern

Pictograph

Principle

Proportion

Radial Symmetry

Reverse Engineering

Rhythm

Shape

Space

Symbol

Symbolism

Symmetry

Texture

Typography

	and its commercial success in the marketplace.
	▪ Reverse engineering involves disassembling and analyzing a product or system in order to understand and document the visual, functional, and/or structural aspects of its design.
	
	In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.
		chronology of a design.
		
		▪ Deliver organized oral presentations of work tailored to the audience.
		
		▪ Create drawings or diagrams as representations of objects, ideas, events, or systems.
		▪ Select and utilize technology (software and hardware) to create high impact visual aids.
		
		▪ Identify and describe the visual principles and elements of design apparent in a natural or man-made object.
		▪ Define aesthetics and explain how the visual elements and principles of design affect the aesthetics and commercial success of a product.
		
		▪ Describe the process of reverse engineering.
		▪ Justify the use of reverse engineering and explain the various reasons to employ reverse engineering, including discovery, documentation, investigation, and product improvement.
		▪ Perform a functional analysis of a product in order to determine the purpose, inputs and outputs, and the operation of a product or system.
		  ▪ Perform a structural analysis of a product in order to determine the materials used and the form of component parts as well as the configuration and interaction of component parts when assembled (if applicable).
		  ▪ Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation.
		
		▪ Demonstrate positive team behaviors and contribute to a positive team dynamic.
			Unity
			
			Value
			
			Variety

Unit 7: Documentation	▪ An engineering design process involves a characteristic set of practices and steps.	▪ Identify the steps in an engineering design process and summarize the activities involved in each step of the process.	**Aligned Dimension**

(Week 26, 4 Weeks)

- Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem.
- A problem and the requirements for a successful solution to the problem should be clearly communicated and justified.
- Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time.
- A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints.
- Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation and/or testing requirements of a potential solution.
- Problem solutions are optimized through evaluation and reflection and should be clearly communicated.
- Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other.
- The scientific method guides the testing and evaluation of prototypes of a problem solution.
- An equation is a statement of equality between two quantities that can be used to describe real phenomenon and solve problems.
- Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing.
- Dimensions, specific notes

- Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements.
- Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief.
- Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to validate design decisions and justify a problem solution.
- Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders.
- Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution.
- Write a design brief to communicate the problem, problem constraints, and solution criteria.
- Generate and document multiple ideas or solution paths to a problem through brainstorming.
- Jointly develop a decision matrix based on accepted outcome criteria and constraints.
- Clearly justify and validate a selected solution path.
- Construct a testable prototype of a problem solution.
- Describe the design process used in the solution of a particular problem andreflect on all steps of the design process.
- Justify and validate a problem solution.
- Identify the shapes of two-dimensional cross sections of three dimensional objects.

Allowance

American National Standards Institute (ANSI)

American Society of Mechanical Engineers (ASME)

Audience Analysis

Auxiliary View

Baseline Dimensioning

Balloon

Bilateral Tolerance

Blind Hole

Broken-Out Section

Chain Dimensioning

Clearance Fit

Counterbore

Countersink

Cutting Plane Line

Datum

Datum Dimensioning

(such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.

- A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings.
- Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.
- Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.
- Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms.
- Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication.
- Reverse engineering involves disassembling and analyzing a product or system in order to understand and document the visual, functional, and/or structural aspects of its design.
- In order to be an effective team

- Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.
- Represent constraints with equations or inequalities.
- Determine the minimum number and types of views necessary to fully detail a part.
- Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings.
- Create a set of working drawings to detail a design project.
- Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc.
- Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices.
- Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing.
- Identify and differentiate between size dimensions and location dimensions.
- Identify and correct errors and omissions in the dimensions applied in a technical drawing based on accepted practice and a set of dimensioning rules.
- Read and interpret a hole note to identify the size and type of hole including through, clearance, blind, counter bore, and countersink holes.
- Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes.
- Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance.
- Define and determine the specified dimension, tolerance, upper limit, and lower limit for any given dimension and related tolerance (or any distance that is

Decision Matrix

Detail Drawing

Detail View

Dual Dimensions

Fillet

Foreshorten

Full Section

Half Section

General Notes

Interference

Interference Fit

International Organization for Standardization (IOS)

Least Material Condition (LMC)

Limit Dimensions

Local Notes

Location Dimension

Market Research

Maximum Material Condition (MMC)

Nominal Size

member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.

dependent on given dimensions) shown on a technical drawing.

- Determine the allowance between two mating parts of an assembly based on dimensions given on a technical drawing.
- Differentiate between clearance and interference fit and identify the type of fit given a drawing, a description, or a physical example of two mating parts.
- Compare the effect of chain dimensioning and datum dimensioning on the tolerance of a particular specified dimension.

- Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object.
- Hand sketch a scaled full or half section view in the correct orientation to fully detail an object or part given the actual object, a detailed verbal description of the object, a pictorial view of the object or a set of orthographic projections.

- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints.
- Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice.
- Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice.
- Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts.

Part Drawing

Parts List

Pitch

Reference Dimension

Round

Section Lines

Section View

Size Dimension

Specified Dimension

Spotface

Survey

Tap

Taper

Technical Writing

Tolerance

Transition fit

Unidirectional Dimension

Unilateral Tolerance

Working Drawings

			▪ Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement. ▪ Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD. ▪ Organize and express thoughts and information in a clear and concise manner. ▪ Adjust voice and writing style to align with audience and purpose. ▪ Support design ideas using a variety of convincing evidence. ▪ Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design. ▪ Create a technical report according to the American National Standards Institute (ANSI) technical report layout and format specifics. ▪ Create drawings or diagrams as representations of objects, ideas, events, or systems. ▪ Analyze information gathered during reverse engineering to identify shortcoming of the design and/or opportunities for improvement or innovation. ▪ Demonstrate positive team behaviors and contribute to a positive team dynamic.	
Unit 8: Advanced Computer Modeling (Week 30, 4 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.07 ASSEMBLY MODELING ▪ Objective 210120.0701 Students will explore	▪ An engineering design process involves a characteristic set of practices and steps. ▪ Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time. Physical models are created to represent and evaluate possible solutions using prototyping technique(s) chosen based	▪ Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. ▪ Generate and document multiple ideas or solution paths to a problem through brainstorming. ▪ Construct a testable prototype of a problem	**Exploded Assembly** **Formula** **Numeric Constraint** **Parameter**

	and demonstrate assembly-modeling skills to solve a variety of design problems. (Adding Components) ▪ Objective 210120.0702 Students will understand and apply the base component effectively in the assembly environment. (Adding Components) ▪ Objective 210120.0703 Students will place and create components in the assembly-modeling environment. (Adding Components) ▪ Objective 210120.0704 Students will create circular and rectangular patterns of components within an assembly model. (Adding Components) ▪ Objective 210120.0705 Students will replace components with modified external parts. (Adding Components) ▪ Objective 210120.0606 Students will perform part manipulation during the creation of an assembly model. (Adding Components) ▪ Objective 210120.0707 Students will explore and demonstrate assembly-modeling skills to solve a variety of design problems. (Adding Components) ▪ Objective	on the presentation and/or testing requirements of a potential solution. Problem solutions are optimized through evaluation and reflection and should be clearly communicated. The scientific method guides the testing and evaluation of prototypes of a problem solution. An equation is a statement of equality between two quantities that can be used to describe real phenomenon and solve problems. Solving mathematical equations and inequalities involves a logical process of reasoning and can be accomplished using a variety of strategies and technological tools. Two- and three-dimensional objects share visual relationships which allow interpretation of one perspective from the other. Geometric shapes and forms are described and differentiated by their characteristic features. The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic. Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing. Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in	solution. ▪ Identify limitations in the design process and the problem solution and recommend possible improvements or caveats. ▪ Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements. ▪ Formulate equations and inequalities to represent linear**,** relationships between quantities. ▪ Solve equations for unknown quantities by determining appropriate substitutions for variables and manipulating the equations. ▪ Identify three dimensional objects generated by rotations of two-dimensional shapes and vice-versa. ▪ Identify and differentiate geometric constructions and constraints such as horizontal lines, vertical lines, parallel lines, perpendicular lines, colinear points, tangent lines, tangent circles, and concentric circles. ▪ Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views. ▪ Determine the minimum number and types of views necessary to fully detail a part. ▪ Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. ▪ Create a set of working drawings to detail a design project. ▪ Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as	**Parametric Modeling** **Phantom Line** **Ratio** **Rib**

210120.0708 Students will explore and demonstrate assembly-modeling skills to solve a variety of design problems. (Assembly Constraints) ▪ Objective 210120.0709 Students will perform part manipulation during the creation of an assembly model. (Assembly Constraints) ▪ Objective 210120.0710 Students will apply assembly constraints to successfully construct a multi-part object. (Assembly Constraints) ▪ Objective 210120.0711 Students will utilize part libraries effectively during the assembly modeling process. (Part Library) ▪ Objective 210120.0712 Students will explore and demonstrate assembly-modeling skills to solve a variety of design problems. (Part Library) ▪ Objective 210120.0713 Students will employ sub-assemblies during the production of assemblies. (Sub-Assemblies) ▪ Objective 210120.0714 Students will explore and demonstrate assembly-modeling skills to solve a variety of design problems.	assemblies. A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings. Hand sketching of multiple representations to fully and accurately detail simple objects or part of objects is a technique used to convey visual and technical information about an object. Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice. Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms. Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication. In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	units, scale, patent details, etc. ▪ Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. ▪ Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. ▪ Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes. ▪ Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance. ▪ Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object. ▪ Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. ▪ Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. ▪ Create relationships among part features and dimensions using parametric formulas. ▪ Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice. ▪ Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from

	(Sub-Assemblies) ▪ Objective 210120.0715 Students will understand and apply drive constraints to simulate the motion of parts in assemblies. (Driving Constraints) ▪ Objective 210120.0716 Students will explore and demonstrate assembly-modeling skills to solve a variety of design problems. (Driving Constraints) ▪ Objective 210120.0717 Students will explore, understand, and apply adaptive design concepts during the development of sketches, features, parts, and assemblies. (Adaptive Design) ▪ Objective 210120.0718 Students will explore and demonstrate assembly-modeling skills to solve a variety of design problems. (Adaptive Design)		the movement between parts. ▪ Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement. ▪ Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD. ▪ Create an exploded view of a given assembly. Identify each component of the assembly with identification numbers, and create a parts list to detail each component using CAD. **(OPTIONAL)** ▪ Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design ▪ Create drawings or diagrams as representations of objects, ideas, events, or systems. ▪ Demonstrate positive team behaviors and contribute to a positive team dynamic.	
Unit 9: Design Team (Week 34, 4 Weeks)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.01 OVERVIEW ▪ Objective 210120.0202 Students will assess the value of working as a team and understand the benefits of collaboration. (Design	▪ An engineering design process involves a characteristic set of practices and steps. ▪ Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem.. ▪ A problem and the requirements for a successful solution to the problem should be clearly communicated and justified. ▪ Brainstorming may take many forms and is used to generate a	▪ Identify the steps in an engineering design process and summarize the activities involved in each step of the process. ▪ Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. ▪ Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief. ▪ Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed,	**Arbitration** **Attorney General** **By-product** **Carcinogen** **Consensus** **Critique** **Ecosystem**

	Process)	large number of innovative, creative ideas in a short time. ▪ A solution path is selected and justified by evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints. ▪ Problem solutions are optimized through evaluation and reflection and should be clearly communicated. ▪ Project planning tools and management skills are often used in the process of solving engineering design problems. ▪ The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic. ▪ Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing. ▪ Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies. ▪ A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings. Hand sketching of multiple representations to fully and accurately detail simple objects or part of objects is a technique used to convey visual and	electronic, and multimedia resources; etc.) to validate design decisions and justify a problem solution. ▪ Summarize key ideas in information sources including scientific and engineering texts, tables, diagrams, and graphs. ▪ Define and justify a design problem, and express the concerns, needs, and desires of the primary stakeholders. ▪ Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. ▪ Explain designrequirements and function claims using STEM principles and practices. ▪ Write a design brief to communicate the problem, problem constraints, and solution criteria. ▪ Generate and document multiple ideas or solution paths to a problem through brainstorming. ▪ Jointly develop a decision matrix based on accepted outcome criteria and constraints. ▪ Use a decision matrix to evaluate and compare multiple design solutions in order to select a solution path that satisfies the design requirements. ▪ Clearly justify and validate a selected solution path. ▪ Justify and validate a problem solution. ▪ Identify limitations in the design process and the problem solution and recommend possible improvements or caveats. ▪ Create and utilize a Gantt chart to plan, monitor, and control task completion during a design project. ▪ Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views.	**Environmental Protection Agency (EPA)** **Ergonomics** **Ethical** **Ethics** **Evaluate** **Gantt Chart** **Hazard** **Impact** **Landfill** **Mediation** **Negotiation** **Norms** **Occupation Safety and Health Administration (OSHA)** **Product Lifecycle** **Protocol** **Raw Material** **Recycle** **Refurbish** **Refuse** **Residue**

technical information about an object. Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice. Styles and modes of professional correspondence are tailored to the type of audience and intended goals.. Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms. Specific oral communication techniques are used to effectively convey information and communicate with an audience. Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication. Engineering has a global impact on society and the environment. Engineering consists of a variety of specialist sub-fields, with each contributing in different ways to the design and development of solutions to different types of problems. Engineering design and practices are governed by ethics, values, and laws. Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object and its commercial success in the marketplace. Effective design teams can improve the efficiency and effectiveness of the design	▪ Determine the minimum number and types of views necessary to fully detail a part. ▪ Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. ▪ Create a set of working drawings to detail a design project. ▪ Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc. ▪ Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. ▪ Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. ▪ Identify and differentiate between size dimensions and location dimensions. ▪ Model and annotate (with a hole note) through, clearance, blind, counter bore, and countersink holes. ▪ Identify and differentiate among limit dimensions, a unilateral tolerance, and a bilateral tolerance. ▪ Hand sketch orthographic projections at a given scale and in the correct orientation to fully detail an object or part using the actual object, a detailed verbal description of the object, or a pictorial an isometric view of the object. ▪ Generate non-technical concept sketches to represent an object or part to convey design ideas. ▪ Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. ▪ Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale,	**Synergy** **Trade-off** **Virtual Team** **Waste**

process. Effective team members have good collaboration skills.

In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.

Virtual design teams include people in different locations who collaborate using communication methods other than face-to-face contact.

appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice.

- Create relationships among part features and dimensions using parametric formulas
- Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice.
- Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement.
- Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD.
- Create an exploded view of a given assembly. Identify each component of the assembly with identification numbers, and create a parts list to detail each component using CAD.

- Identify an appropriate mode of two-way communication based on the audience and intended goal of the communication.
- Use an appropriate and professional tone and vernacular based on the audience of the correspondence.
- Document correspondence and conversations in an accurate and organized manner.
- Review and evaluate the written work of peers and make recommendations for improvement.

- Organize and express thoughts and information in a clear and concise manner.
- Adjust voice and writing style to align with audience and purpose.
- Support design ideas using a variety of convincing evidence.
- Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards

and protocols to prove the origin and chronology of a design.
- Utilize journaling as a means of documentation and reflection to demonstrate original thought and reasoning.
- Utilize project portfolios to present and justify design projects.
- Document information sources using appropriate formats.

- Deliver organized oral presentations of work tailored to the audience.
- Establish objectives for the presentation that are appropriate for the audience.
- Facilitate engaging and purposeful dialog with the audience.

- Create drawings or diagrams as representations of objects, ideas, events, or systems.
- Select and utilize technology (software and hardware) to create high impact visual aids.
- Select and utilize videos and images from CAD software to convey information appropriate for the given audience.
- Use presentation software effectively to support oral presentations.

- Assess the development of an engineered product and discuss its impact on society and the environment.

- Describe the contributions of engineers from different engineering fields in the design and development of a product, system, or technology.

- Identify and describe the steps of a typical product lifecycle (including raw material extraction, processing, manufacture, use and maintenance, and disposal.
- Identify and explain how the basic theories of ethics relate to engineering.

- Incorporate the use of the visual elements and principles of design in the design of an

			engineered product. ▪ Identify team member skill sets needed to produce an effective team. ▪ Identify and assign team member roles. ▪ Define the term group norms and discuss the importance of norms in creating an effective team environment. ▪ Identify strategies to resolve team conflict. ▪ Demonstrate positive team behaviors and contribute to a positive team dynamic. ▪ Establish common goals, equitable workloads, accountability, and create a set of team norms. ▪ Contribute equitably to the attainment of group goals based on assigned roles. ▪ Practice appropriate conflict resolution strategies within a team environment. ▪ Identify appropriate technology to support remote collaboration among virtual design team members (such as asynchronous communications, audio and video conferencing, instant messaging, synchronous file editing, and file transfer). ▪ Participate on a virtual team usingremote collaboration tools to support team collaboration and problem solving.
Unit 10: Design Challenges (Week 38, 1 Week)	UT: CTE: Technical and Engineering, UT: Grades 9-12, Project Lead The Way "Introduction to Engineering Design" Standard 210120.01 OVERVIEW ▪ Objective 210120.0201 Students will list the seven steps of the design process and explain the activities that occur during each phase. (Design Process) ▪ Objective 210120.0203	An engineering design process involves a characteristic set of practices and steps. Research derived from a variety of sources (including subject matter experts) is used to facilitate effective development and evaluation of a design problem and a successful solution to the problem. A problem and the requirements for a successful solution to the problem should be clearly communicated and justified. Brainstorming may take many forms and is used to generate a large number of innovative, creative ideas in a short time. A solution path is selected and justified by	▪ Complete a design project utilizing all steps of a design process, and find a solution that meets specific design requirements. ▪ Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to gather and interpret information to develop an effective design brief. ▪ Utilize research tools and resources (such as the Internet; media centers; market research; professional journals; printed, electronic, and multimedia resources; etc.) to validate design decisions and justify a problem solution. ▪ Define and justify a design problem, and express the concerns, needs, and desires

	Students will realize the importance of focusing on detail when executing the design process. (Design Process) ▪ Objective 210120.0204 Students will apply the steps of the design process to solve a variety of design problems. (Design Process) ▪ Objective 210120.0205 Students will investigate the principles and elements of design and demonstrate their use in the design process incorporating them in design solutions. (Principles and Elements of Design)	evaluating and comparing competing design solutions based on jointly developed and agreed-upon design criteria and constraints. Problem solutions are optimized through evaluation and reflection and should be clearly communicated. The style of the engineering graphics and the type of drawing views used to detail an object vary depending upon the intended use of the graphic. Technical drawings convey information according to an established set of drawing practices which allow for detailed and universal interpretation of the drawing. Dimensions, specific notes (such as hole and thread notes), and general notes (such as general tolerances) are included on technical drawings according to accepted practice and an established set of standards so as to convey size and location information about detailed parts, their features, and their configuration in assemblies.. A degree of variation always exists between specified dimensions and the measurement of a manufactured object which is controlled by the use of tolerances on technical drawings. Hand sketching of multiple representations to fully and accurately detail simple objects or parts of objects is a technique used to convey visual and technical information about an object.. Computer aided drafting and design (CAD) software packages facilitate virtual modeling of parts and assemblies and the creation of technical drawings. They are used to efficiently and accurately detail parts and assemblies according to standard engineering practice.	of the primary stakeholders. ▪ Present and justify design specifications, and clearly explain the criteria and constraints associated with a successful design solution. ▪ Explain design requirements and function claims using STEM principles and practices. ▪ Write a design brief to communicate the problem, problem constraints, and solution criteria. ▪ Generate and document multiple ideas or solution paths to a problem through brainstorming. ▪ Jointly develop a decision matrix based on accepted outcome criteria and constraints. ▪ Use a decision matrix to evaluate and compare multiple design solutions in order to select a solution path that satisfies the design requirements. ▪ Clearly justify and validate a selected solution path. ▪ Describe the design process used in the solution of a particular problem and reflect on all steps of the design process. ▪ Justify and validate a problem solution. ▪ Identify limitations in the design process and the problem solution and recommend possible improvements or caveats. ▪ Identify the proper use of each technical drawing representation including isometric, orthographic projection, oblique, perspective, auxiliary, and section views. ▪ Determine the minimum number and types of views necessary to fully detail a part. ▪ Choose and justify the choice for the best orthographic projection of an object to use as a front view on technical drawings. ▪ Create a set of working drawings to detail a design project. ▪ Create specific notes on a technical drawing to convey important information about a specific feature of a detailed object, and create general notes to convey

	Technical professionals clearly and accurately document and report their work using technical writing practice in multiple forms. Visual elements and principles of design are part of an aesthetic vocabulary that is used to describe the visual characteristics of an object, the application of which can affect the visual appeal of the object and its commercial success in the marketplace. Effective design teams can improve the efficiency and effectiveness of the design process. Effective team members have good collaboration skills. In order to be an effective team member, one must demonstrate positive team behaviors and act according to accepted norms, contribute to group goals according to assigned roles, and use appropriate conflict resolution strategies.	details that pertains to information presented on the entire drawing (such as units, scale, patent details, etc. ▪ Dimension orthographic projections and section views of simple objects or parts according to a set of dimensioning standards and accepted practices. ▪ Identify and correctly apply chain dimensioning or datum dimensioning methods to a technical drawing. ▪ Identify and differentiate between size dimensions and location dimensions. ▪ Determine the allowance between two mating parts of an assembly based on dimensions given on a technical drawing. ▪ Hand sketch isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, a pictorial view of the object, or a set of orthographic projections. ▪ Generate non-technical concept sketches to represent an object or part to convey design ideas. ▪ Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints. ▪ Generate CAD multi-view technical drawings, including orthographic projections, sections view(s), detail view(s), auxiliary view(s) and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a part according to standard engineering practice. ▪ Create relationships among part features and dimensions using parametric formulas. ▪ Dimension and annotate (including specific and general notes) working drawings according to accepted engineering practice. Include dimensioning according to a set of dimensioning rules, proper hole and thread notes, proper tolerance annotation, and the inclusion of other notes necessary to fully describe a part according to standard engineering practice.

- Create sketch elements and relationships among part features in CAD using precise input (and an applicable coordinate system).
- Explain each assembly constraint (including mate, flush, insert, and tangent), its role in an assembly model, and the degrees of freedom that it removes from the movement between parts.
- Create assemblies of parts in CAD and use appropriate assembly constraints to create an assembly that allows correct realistic movement among parts. Manipulate the assembly model to demonstrate the movement.
- Create a CAD assembly drawing. Identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD.
- Create an exploded view of a given assembly. Identify each component of the assembly with identification numbers, and create a parts list to detail each component using CAD.

- Organize and express thoughts and information in a clear and concise manner.
- Utilize an engineering notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design.
- Document information sources using appropriate formats.

- Incorporate the use of the visual elements and principles of design in the design of an engineered product.

- Identify and assign team member roles.
- Define the term group norms and discuss the importance of norms in creating an effective team environment.
- Identify strategies to resolve team conflict.

- Demonstrate positive team behaviors and contribute to a positive team dynamic.
- Establish common goals, equitable workloads, accountability, and create a set of team norms.

- Contribute equitably to the attainment of group goals based on assigned roles.
- Practice appropriate conflict resolution strategies within a team environment.

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