PLTW Introduction to Engineering Design (IED)

Curriculum/Content Area: Applied Technology & Engineering	Course Length: Two Terms
Course Title: Introduction to Engineering Design (IED)	Date last reviewed: May 8, 2015
Prerequisites: None	Board approval date: June 16, 2015

Desired Results

Course description and purpose: This is a foundational level course focused on engineering and engineering design. Students will be introduced to careers in the engineering profession, common approaches to engineering problem solving, and the engineering design process. Course work will be dependent on the use of a 3-D solid modeling program, in order to create original solutions to problems. Throughout the course various forms of technology are utilized, by the students, to create working solutions. The project work gives students the opportunity to develop skills and understanding of course concepts through activity-, project-, problem- based (APPB) learning. Used in combination with a teaming approach, APPB learning challenges students to continually hone their interpersonal skills, creative abilities, and problem solving skills as they apply engineering concepts. It allows students to develop strategies to enable and direct their own learning.

Enduring Understandings (EUs):	**Essential Questions (EQs)**:
• An engineering design process involves a characteristic set of practices and steps used to develop innovative solutions to problems. • Sketches, drawings, and images are used to record and convey specific types of information depending upon the audience and the purpose of the communication. • Variation in a process and the measurement of its product is unavoidable, these properties are characterized by precision and accuracy. • Technical professionals use a variety of models to represent systems, components, processes and other designs including graphical, computer, physical, and mathematical models.	• When solving a problem, how can one be reasonably sure that the BEST solution possible has been created? • In what ways can technical drawings help or hinder the communication of problem solution in a global community. • How can statistics be interpreted to justify conflicting viewpoints? • How can engineers utilize presentations to validate a design idea? • How can math concepts and skills be applied to solve engineering problems? • Is it acceptable for a company to reverse engineer and reproduce a consumer product? • Why would engineers create a design

• 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 problem, and as a tool to specify final solutions. • 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. • 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.	or solve a problem individually as opposed to using a team approach?

Assessment Evidence

Performance assessments: 1. Major projects consisting of: full project documentation, complete system design with modifications and fabrication of a functioning system prototype. 2. Project presentations targeted at either informing or persuading audiences about a design solution.	Other assessments: 1. Formative activities including group work used to introduce content, provide feedback, and evaluate understanding. 2. Summative quizzes used to determine content mastery.

Unit #1: Design Process
A. Design Process B. Conceptual Sketching C. Brainstorming D. Career Pathways
Standards:
Wisconsin Technology and Engineering Standards ENG1.a.1.e: Design is a creative process. ENG1.a.2.e: Everyone can design solutions to a problem. ENG1.a.9.h: Examine how the design needs to continually be evaluated and the ideas of the design must be redefined and improved.

ENG2.a.2.e: Explore when designing an object, it is important to be creative and consider all ideas.
ENG2.b.3.m: Modeling, testing, evaluating and modifying are used to transform ideas into practical solutions.
ENG2.b.4.h: A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.
ENG3.a.3.e: Explain troubleshooting is a way of finding out why something does not work so that it can be improved.
ENG4.a.3.m: Specify criteria and constraints for the design.
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.a.7.h: Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.

Learning Targets:

I can:

- Identify the steps in an engineering design process and describe the activities involved in each step of the process.
- Explain the concept of proportion and how it relates to freehand sketching.
- Identify and describe a variety of brainstorming techniques and rules for brainstorming.
- Identify and differentiate between the work of an engineer and the work of a scientist.
- Utilize an Engineer's Notebook to clearly and accurately document the design process according to accepted standards and protocols to prove the origin and chronology of a design.
- Explain the contributions of engineers from different engineering fields in the design and development of a product, system, or technology.

Unit #2: Technical Sketching and Drawing

A. Isometric
B. Perspective
C. Multiview

Standards:

Wisconsin Technology and Engineering Standards
ENG2.a.7.h. Recognize that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly
ENG2.b.1.e Expressing ideas to others verbally and through sketches and models is an important part of the design process.

Learning Targets:

I can...

- Produce a technical drawing using line types per ANSI Line conventions and lettering.
- Create and design technical drawings and interpret representations including isometric, orthographic projection, oblique, and perspective views.
- Apply tonal shading to enhance appearance and create a realistic appearance.
- Determine, evaluate and produce 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.

Unit #3: Measurement and Statistics

A. Linear Measurement
B. Unit Conversion
C. Dimensions
D. Applied Statistics
E. Precision & Accuracy

Standards:

CCSS
AS.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
AS.SL.2 Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
AS.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Learning Targets:

I can...

- 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.
- Use units to guide the solution to multi-step problems through dimensional analysis and choose and interpret units consistently in formulas.
- Convert quantities between units in the SI and the US Customary measurement systems.
- Dimension orthographic projections of simple objects or parts according to a set of dimensioning standards and accepted practices

- Calculate statistics related to central tendency including mean, median, and mode.
- Calculate statistics related to variation of data including (sample and population) standard deviation and range.
- Use statistics to quantify information, support design decisions, and justify problem solutions.

Unit # 4: Modeling Skills

A. Graphical Modeling
B. Mathematical Modeling
C. Assembly Constraints
D. Portfolios

Standards:

CCSS
AS.W.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences
AS.SL.2 Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
AS.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
AS.SL.5 Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
AS.SL.6 Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.
AS.L.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
AS.L.3 Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.
AS.L.6 Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Wisconsin Technology and Engineering Standards
ENG2.b.2.e: Discuss how models are used to communicate and test design ideas and processes.
ENG2.b.3.m: Modeling, testing, evaluating and modifying are used to transform ideas into practical solutions.
ENG3.b.2.e: Describe that the process of experimentation, which is common in science, can

also be used to solve technological problems.
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.b.2.e: Use computers and technology to access and organize information.
ENG5.b.5.m: Use computers, calculators and technology in various applications.
ENG6.a.2.m: Design and use instruments and technology to gather data.

Learning Targets:

I can:

- Develop and/or use graphical, computer, physical and mathematical models as appropriate to represent or solve problems.
- 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 and pictorial views, as necessary, showing appropriate scale, appropriate view selection, and correct view orientation to fully describe a simple part according to standard engineering practice
- Construct a testable prototype of a problem solution
- Create a set of working drawings to detail a design project.
- Organize and express thoughts and information in a clear and concise manner.

Unit # 5: Geometry of Design

A. Properties of Shapes
B. Geometric Constraints
C. Properties of Solids
D. Physical Property Analysis

Standards:

CCSS
AS.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
AS.SL.2 Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
AS.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

AS.SL.6 Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

Wisconsin Technology and Engineering Standards
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.
ENG4.c.3.e: Improve the design solutions.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.b.2.e: Use computers and technology to access and organize information.
ENG5.b.5.m: Use computers, calculators and technology in various applications.
ENG5.b.8.h: Troubleshoot, analyze and maintain systems to ensure proper function, accuracy and precision.

Learning Targets:

I can:

- Identify and apply types of polygons including a square, rectangle, pentagon, hexagon, and octogon in my drawings and sketches.
- Identify and differentiate geometric constructions and constraints (such as horizontal lines, vertical lines, parallel lines, perpendicular lines, co-linear points, tangent lines, tangent circles, and concentric circles) and the results when applied to sketch features within a 3D solid modeling environment.
- Distinguish between the meanings of the terms weight and mass.
- Apply the properties of length, volume, mass, weight, density, and surface area as physical properties.
- 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
- Create three-dimensional solid models of parts within CAD from sketches or dimensioned drawings using appropriate geometric and dimensional constraints and model features.

Unit # 6: Reverse Engineering

A. Visual Design Principles & Elements
B. Visual Analysis
C. Functional Analysis
D. Structural Analysis

Standards:

CCSS

AS.W.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
AS.W.2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis
AS.W.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
AS.W.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.
AS.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own AS.SL.2 Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
AS.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
AS.SL.5 Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
AS.L.6 Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Wisconsin Technology and Engineering Standards

ENG2.b.2.e: Discuss how models are used to communicate and test design ideas and processes.
ENG2.b.3.m: Modeling, testing, evaluating and modifying are used to transform ideas into practical solutions.
ENG3.b.2.e: Describe that the process of experimentation, which is common in science, can also be used to solve technological problems.
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.b.2.e: Use computers and technology to access and organize information.
ENG5.b.5.m: Use computers, calculators and technology in various applications.
ENG6.a.2.m: Design and use instruments and technology to gather data.

Learning Targets:

I can:

- Identify and describe the visual principles and elements of design apparent in a natural or man-made object.

- Perform reverse engineering including discovery, documentation, investigation, and product improvement.
- Apply the visual elements and principles of design and determine the effect of aesthetics and commercial success of a product.
- 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).

Unit # 7: Documentation

A. Dimensioning Standards
B. Section Views
C. Tolerances
D. Assembly Models

Standards:

CCSS
AS.W.2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
AS.W.6 Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
AS.W.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.
AS.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
AS.SL.2 Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
AS.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
AS.SL.5 Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
AS.SL.6 Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

Wisconsin Technology and Engineering Standards
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.

ENG4.c.3.e: Improve the design solutions.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.b.2.e: Use computers and technology to access and organize information.
ENG5.b.5.m: Use computers, calculators and technology in various applications.
ENG5.b.8.h: Troubleshoot, analyze and maintain systems to ensure proper function, accuracy and precision.

Learning Targets:

I can:

- Create, within a technical drawing, the shapes of two-dimensional cross sections of three dimensional objects
- Read and interpret a hole note to identify the size and type of hole including through, clearance, blind, counter-bore, and countersink holes.
- 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.
- 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 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 pertain to information presented on the entire drawing (such as units, scale, patent details, etc.).
- 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.

Unit # 8: Advanced Computer Modeling

A. Computer Modeling
B. Parametric Constraints
C. Auxiliary Views
D. Working Drawings

Standards:

CCSS
AS.L.6 Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career

readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Wisconsin Technology and Engineering Standards
ENG2.b.2.e: Discuss how models are used to communicate and test design ideas and processes.
ENG2.b.3.m: Modeling, testing, evaluating and modifying are used to transform ideas into practical solutions.
ENG3.b.2.e: Describe that the process of experimentation, which is common in science, can also be used to solve technological problems.
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.b.2.e: Use computers and technology to access and organize information.
ENG5.b.5.m: Use computers, calculators and technology in various applications.
ENG6.a.2.m: Design and use instruments and technology to gather data.

Learning Targets:

I can:

- Identify, define, and explain the proper use of an auxiliary view in technical drawing.
- Use advanced modeling features to create three-dimensional solid models of complex parts and assemblies within CAD and with little guidance given the actual part using appropriate geometric and dimensional constraints.
- Formulate equations and inequalities to represent relationships between quantities.
- Using a CAD application, create relationships among part features and dimensions using parametric formulas.
- Create an exploded assembly view of a multi-part product and identify each component of the assembly with identification numbers and create a parts list to detail each component using CAD.
- Perform a peer review of technical drawings and offer constructive feedback based on standard engineering practices.

Unit # 9: Design Team

A. Product Lifecycle
B. Design Ethics
C. Team Norms
D. Product Research

Standards:

CCSS

AS.R.1 Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
AS.R.2 Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
AS.R.3 Analyze how and why individuals, events, and ideas develop and interact over the course of a text.
AS.R.4 Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
AS.R.8 Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
AS.R.10 Read and comprehend complex literary and informational texts independently and proficiently.

Wisconsin Technology and Engineering Standards

ENG2.b.4.h: A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.
ENG3.a.3.e: Explain troubleshooting is a way of finding out why something does not work so that it can be improved.
ENG3.b.5.h: Describe how many technological problems require a multidisciplinary approach.
ENG4.b.2.e: Build or construct an object using the design process.
ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom.
ENG5.a.3.e: Recognize and use everyday symbols such as numbers and symbols to communicate key ideas.
ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it.
ENG5.a.7.h: Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
ENG5.b.2.e: Use computers and technology to access and organize information.
ENG5.b.5.m: Use computers, calculators and technology in various applications.
ENG5.b.8.h: Troubleshoot, analyze and maintain systems to ensure proper function, accuracy and precision.

Learning Targets:

I can:

- Identify and describe the steps of a typical product lifecycle (including raw material extraction, processing, manufacture, use and maintenance, and disposal).
- Identify team member skill sets needed to produce an effective team.

- Identify the advantages and disadvantages of virtual design teams compared to traditional design teams.
- 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.
- Summarize key ideas in information sources including scientific and engineering texts, tables, diagrams, and graphs.
- Organize and express thoughts and information in a clear and concise manner.
- Demonstrate positive team behaviors and contribute to a positive team dynamic.

Unit # 10: Design Challenge
A. Design Challenge
Standards:
CCSS AS.W.6 Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. AS.W.8 Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. AS.W.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. AS.W.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences. **Wisconsin Technology and Engineering Standards** ENG2.b.2.e: Discuss how models are used to communicate and test design ideas and processes. ENG2.b.3.m: Modeling, testing, evaluating and modifying are used to transform ideas into practical solutions. ENG3.b.2.e: Describe that the process of experimentation, which is common in science, can also be used to solve technological problems. ENG4.b.2.e: Build or construct an object using the design process. ENG4.b.3.m: Apply a design process to solve problems in and beyond the laboratory-classroom. ENG5.a.6.h: Diagnose a system that is malfunctioning and use tools, materials, or machines to repair it. ENG5.b.2.e: Use computers and technology to access and organize information. ENG5.b.5.m: Use computers, calculators and technology in various applications. ENG6.a.2.m: Design and use instruments and technology to gather data.

Learning Targets:

I can:

- Apply the engineering design process involving a characteristic set of practices and steps to develop innovative solutions to problems.
- Defend the steps in an engineering design process and describe the activities involved in each step of the process.
- Develop and document an effective solution to a problem that meets specific design requirements
- Document and describe the design process used in the solution of a problem and reflect on all steps of the design process.
- Work and communicate effectively as a part of a team.