PATHWAY TO LEARNING ENGINEERING

Engineering Design Standards alignment

Siemens Engineering Design

This course challenges students to work in teams to solve complex design problems. Students research, design, develop and communicate design solutions. Using Siemens' engineering software teams prepare and evaluate designs and make extensive use of 3D printing to prepare models for presentation to authentic audiences. The goal of the course is to provide students with the opportunity to address unique problems and rapidly create and analyze proposed solutions, using professional industry software tools.

Standards for Technological and Engineering Literacy (STEL)

STEL 1	Nature and Characteristics of Technology and Engineering
STEL-1N	Explain how the world around them guides technological development and engineering design.
STEL-1O	Assess how similarities and differences among scientific, mathematics, engineering and technological knowledge and skills contributed to the design of a product or system.
STEL-1P	Analyze the rate of technological development and predict future diffusion and adoption of new technologies.
STEL-1Q	Conduct research to inform intentional inventions and innovations that address specific needs and wants.
STEL-1R	Develop a plan that incorporates knowledge from science, mathematics and other disciplines to design or improve a technological product or system.

STEL 2	Core Concepts of Technology and Engineering
STEL-2T	Demonstrate the use of conceptual, graphical, virtual, mathematical and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making.
STEL-2W	Select resources that involve tradeoffs between competing values, such as availability, cost, desirability and waste while solving problems.
STEL-2X	Cite examples of the criteria and constraints of a product or system and how they affect final design.
STEL-2Y	Implement quality control as a planned process to ensure that a product, service or system meets established criteria.
STEL-2Z	Use management processes in planning, organizing and controlling work.

STEL 3	Integration of Knowledge, Technologies and Practices
STEL-3H	Analyze how technology transfer occurs when a user applies an existing innovation developed for one function for a different purpose.
STEL-3I	Evaluate how technology enhances opportunities for new products and services through globalization.
STEL-3J	Connect technological progress to the advancement of other areas of knowledge.

STEL 4	Impacts of Technology
STEL-4P	Evaluate ways that technology can impact individuals, society and the environment.
STEL-4Q	Critique whether existing and proposed technologies use resources sustainably.
STEL-4R	Assess a technology that minimizes resource use and resulting waste to achieve a goal.
STEL-4S	Develop a solution to a technological problem that has the least negative environmental and social impact.
STEL-4T	Evaluate how technologies alter human health and capabilities.

STEL 5	Influence of Society on Technological Development
STEL-5H	Evaluate a technological innovation that arose from a specific society's unique need or want.
STEL-5I	Evaluate a technological innovation that was met with societal resistance impacting its development.

STEL 6	History of Technology
STEL-6F	Relate how technological development has been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge.
STEL-6G	Verify that the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials and processes.
STEL-6H	Evaluate how technology has been a powerful force in reshaping the social, cultural, political and economic landscapes throughout history.
STEL-6I	Analyze how the Industrial Revolution resulted in the development of mass production, sophisticated transportation and communication systems, advanced construction practices and improved education and leisure time.
STEL-6J	Investigate the widespread changes that have resulted from the Information Age, which has placed emphasis on the processing and exchange of information.

STEL 7	Design in Technology and Engineering Education
STEL-7W	Determine the best approach by evaluating the purpose of the design.
STEL-7X	Document trade-offs in the technology and engineering design process to produce the optimal design.
STEL-7Y	Optimize a design by addressing desired qualities within criteria and constraints.
STEL-7Z	Apply principles of human-centered design.
STEL-7AA	Illustrate principles, elements and factors of design.
STEL-7BB	Implement the best possible solution to a design.
STEL-7CC	Apply a broad range of design skills to their design process.
STEL-7DD	Apply a broad range of making skills to their design process.

STEL 8	Applying, Maintaining and Assessing Technological Products and Systems
STEL-8N	Use various approaches to communicate processes and procedures for using, maintaining and assessing technological products and systems.
STEL-8O	Develop a device or system for the marketplace.
STEL-8P	Apply appropriate methods to diagnose, adjust and repair systems to ensure precise, safe and proper functionality.
STEL-8Q	Synthesize data and analyze trends to make decisions about technological products, systems or processes.

Practices	Practices
1	System Thinking
2	Creativity
3	Making and Doing
4	Critical Thinking
5	Optimism
6	Collaboration
7	Ethics
8	Communication

Next Generation Science Standards (NGSS)

HS-ETS	Engineering Design
HS-ETS 1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal need and wants.
HS-ETS 1-2	Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.
HS-ETS 1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

HS-PS3	Energy
HS-PS3-3	Design, build and refine a device that works within given constraints to convert on form of energy into another form of energy.

Science and Engineering Practices (SEP)	SEP
1	Asking Questions and Defining Problems
2	Developing and Using Models
3	Planning and Carrying Out Investigations
4	Analyzing and Interpreting Data
5	Using Mathematics and Computational Thinking
6	Constructing Explanations and Designing Solutions
7	Engaging in Argument from Evidence
8	Obtaining, Evaluating and Communicating Information

Crosscutting Concepts	
1	Patterns
2	Cause and Effect
3	Scale, Proportion and Quantity
4	Systems and System Models
5	Energy and Matter
6	Structure and Function
7	Stability and Change

National Assessment of Educational Progress – Technology and Engineering Literacy (NAEP-TEL) Assessment Standards

	Technology and Society
T.12.1	The decision to develop a new technology is influenced by societal opinions and demands. These driving forces differ from culture to culture.
T.12.2	Changes caused by the introduction and use of a new technology can range from gradual to rapid and from subtle to obvious, and can change over time. These changes may vary from society to society as a result of differences in a society's economy, politics and culture.
T.12.3	Choose an appropriate technology to help solve a given societal problem, and justify the selection based on an analysis of criteria and constraints, available resources, likely trade-offs and relevant environmental and cultural concerns.
T.12.4	Analyze cultural, social, economic or political changes (separately or together) that may be triggered by the transfer of a specific technology from one society to another. Include both anticipated and unanticipated effects.
T.12.5	Many technologies have been designed to have a positive impact on the environment and to monitor environmental change over time to provide evidence for making informed decisions.
T.12.7	Identify a complex global environmental issue; develop a systematic plan of investigation; and propose an innovative, sustainable solution.
T.12.11	Give examples to illustrate the effects on society of the recording, distribution and access to information and knowledge that have occurred in history and discuss the effects of those revolutions on societal change.
T.12.13	Disparities in the technologies available to different groups of people have consequences for public health and prosperity, but deciding whether to introduce a new technology should consider local resources and the role of culture in acceptance of the new technology.

	Design and Systems
D.12.1	Advances in science have been applied by engineers to design new products, processes and systems, while improvements in technology have enabled breakthroughs in scientific knowledge.
D.12.2	Engineers use science, mathematics and other disciplines to improve technology, while scientists use tools devised by engineers to advance knowledge in their disciplines. This interaction has deepened over the past century.
D.12.4	Take into account trade-offs among several factors when selecting a material for a given application.
D.12.6	Engineering design is a complicated process in which creative steps are embedded in content knowledge and research on the challenge. Decisions on trade-offs involve systematic comparisons of all costs and benefits, and final steps may involve redesigning for optimization.
D.12.7	Specifications involve criteria, which may be weighted in various ways, and constraints, which can include natural laws and available technologies. Evaluation is a process for determining how well a solution meets the requirements.
D.12.8	Meet a sophisticated design challenge by identifying criteria and constraints, predicting how these will affect the solution, researching and generating ideas, and using trade-offs to balance competing values in selecting the best solution.
D.12.9	Construct and test several models to see if they meet the requirements of a problem. Combine features to achieve the best solution.

D.12.10	Communicate the entire design process from problem definition to evaluation of the final design, taking into account relevant criteria and constraints, including aesthetic and ethical considerations as well as purely logical decisions.
D.12.11	The stability of a system depends on all of its components and how they are connected, with more complicated systems tending to require more energy and to be more vulnerable to error and failure. Negative feedback loops tend to increase the stability and efficiency of systems.
D.12.13	Examine a system to predict how it will perform with a given set of inputs in a given situation and how performance will change if the components or interactions of the system are changed.
D.12.17	Analyze a system malfunction using logical reasoning (such as a fault tree) and appropriate diagnostic tools and instruments. Devise strategies and recommend tools for fixing the problem.
D.12.18	Analyze a complicated system to identify ways that it might fail in the future. Identify the most likely failure points and recommend safeguards to avoid future failures.

	Information and Communication Technology (ICT)
I.12.7	Use digital tools and resources to identify a complicated global issue and develop a systematic plan of investigation. Present findings in terms of pros and cons of two or more innovative sustainable solutions.
I.12.8	Use digital tools to collect, analyze and display data in order to design and conduct complicated investigations in various subject areas. Explain rationale for the design and justify conclusions based on observed patterns in the data.
I.12.9	Having conducted a simulation of a system using a digital model, draw conclusions about the system, or propose possible solutions to a problem or ways to reach a goal based on outcomes of the simulation. Critique the conclusions based on the adequacy of the model.

International Society for Technology in Education (ISTE) Standards

Empowered Learner	Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences
1.1a	Set learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process to improve learning outcomes.
1.1b	Build networks and customize their learning environments in ways that support the learning process.
1.1c	Use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
1.1d	Understand fundamental concepts of how technology works, demonstrate the ability to choose and use current technologies effectively and are adept at thoughtfully exploring emerging technologies

Digital Citizen	Students recognize the responsibilities and opportunities for contributing to their digital communities.
1.2.a	Manage their digital identity and understand the lasting impact of their online behaviors on themselves and others and make safe, legal and ethical decisions in the digital world.
1.2.b	Demonstrate empathetic, inclusive interactions online and use technology to responsibly contribute to their communities.
1.2.c	Safeguard their well-being by being intentional about what they do online and how much time they spend online.
1.2.d	Take action to protect their digital privacy on devices and manage their personal data and security while online.

Knowledge Constructor	Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.
1.3.a	Use effective research strategies to find resources that support their learning needs, personal interests and creative pursuits.
1.3.b	Evaluate the accuracy, validity, bias origin and relevance of digital content.
1.3.c	Curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
1.3.d	Build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

Innovative Designer	Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions
1.4.a	Know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
1.4.b	Select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
1.4.c	Develop, test and refine prototypes as part of a cyclical design process.
1.4.d	Exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

Computational Thinker	**Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.**
1.5.a	Formulate problem definitions suited for technologyassisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
1.5.b	Collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem-solving and decision-making.
1.5.c	Break problems into component parts, extract key information and develop descriptive models to understand complex systems or facilitate problem-solving.
1.5.d	Understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Creative Communicator	**Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.**
1.6.a	Choose the appropriate platforms and digital tools for meeting the desired objectives of their creation or communication.
1.6.b	Create original works or responsibly repurpose or remix digital resources into new creations.
1.6.c	Use digital tools to visually communicate complex ideas to others.
1.6.d	Publish or present content that customizes the message and medium for their intended audiences.

Global Collaborator	**Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.**
1.7.a	Use digital tools to connect with peers from a variety of backgrounds recognizing diverse viewpoints and broadening mutual understanding.
1.7.b	Use collaborative technologies to work with others, including peers, experts or community members, to examine issues and problems from multiple viewpoints.
1.7.c	Contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.
1.7.d	Explore local and global issues and use collaborative technologies to work with others to investigate solutions.

English Language Arts (ELA) Common Core State Standards (CCSS)

Reading Standards for Literacy in History/Social Studies 9-10	Key Ideas and Details
1	Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
3	Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.
	Integration of Knowledge and Ideas
7	Integrate quantitative or technical analysis (for example, charts, research data) with qualitative analysis in print or digital text.
9	Compare and contrast treatments of the same topic in several primary and secondary sources.
	Range of Reading and Level of Text Complexity
10	By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 9-10	Text Types and Purposes
1	Write arguments focused on discipline-specific content.
2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments or technical processes.
	Production and Distribution of Writing
4	Produce clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience.
	Research to Build and Present Knowledge
7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
	Range of Writing
10	Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes and audiences.

College and Career Readiness (CCR) Mathematical Standards

Geometric Measurement and Dimension G-GMD	**Explain volume formulas and use them to solve problems**
1	Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid and cone. Use dissection arguments, Cavalieri's principle and informal limit arguments.
3	Use volume formulas for cylinders, pyramids, cones and spheres to solve problems.

Modeling with Geometry G-MG	**Apply geometric concepts in modeling situations**
1	Use geometric shapes, their measures and their properties to describe objects (for example, modeling a tree trunk or a human torso as a cylinder).
2	Apply concepts of density based on area and volume in modeling situations (for example, persons per square mile, BTUs per cubic foot).
3	Apply geometric methods to solve design problems (for example, designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Create equations that describe numbers or relationships CED	
A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
	Creating Equations A-CED
1	Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions and simple rational and exponential functions.
2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
3	Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.
4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law $V = IR$ to highlight resistance R.

Reasoning with Equations and Inequalities	Interpret the structure of expressions
1	Interpret expressions that represent a quantity in terms of its context.
2	Use the structure of an expression to identify ways to rewrite it. For example, see x4 – y4 as (x2)2 – (y2)2, thus recognizing it as a difference of squares that can be factored as (x2 – y2)(x2 + y2).
	Write expressions in equivalent forms to solve problems
3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
4	Derive the formula for the sum of a finite geometric series (when the common ratio is not 1) and use the formula to solve problems. For example, calculate mortgage payments.

Number and Quantity	Quantities
1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
2	Define appropriate quantities for the purpose of descriptive modeling.
	Vector and Matrix Quantities
3	Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments and use appropriate symbols for vectors and their magnitudes.
4b	Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

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