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CTE Standards Unpacking
Engineering Design and Development

Course: Engineering Design and Development
Course Description: Engineering Design and Development is a pathway course in the STEM Engineering Pathway, STEM Energy Pathway, and STEM Robotics Pathway. Students are engaged in an instructional program that integrates academics, problem solving, communication, and technical preparation and focuses on career awareness. This course is designed to provide the student with an engaging opportunity to research, design, innovate and develop technological artifacts (products). This course will prepare students for direct entry into a career, advanced educational opportunities, and lifelong learning.
Career Cluster: STEM
Prerequisites: None
Program of Study Application: This is a pathway course in the STEM cluster Energy pathway. It is recommended that the course be preceded by a series of foundation courses and a cluster course in STEM, and followed by a more specialized pathway course such as Engineering, Energy and Robotics.

INDICATOR #EDD 1: **Identify a technologically related problem**		
SUB-INDICATOR 1.1 (Webb Level: 3 Strategic Thinking): Examine current state of a problem		
SUB-INDICATOR 1.2 (Webb Level: 3 Strategic Thinking): Research solution options to solve problem		
SUB-INDICATOR 1.3 (Webb Level: 3 Strategic Thinking): Propose new solutions to solve problem		
SUB-INDICATOR 1.4 (Webb Level: 4 Extended Thinking): Identify the best solution		
Knowledge (Factual): Engineering and Science Practices. Reliable sources of information. Engineering is a practice used to solve a problem.	**Understand (Conceptual):** Engineering applies technology, mathematics and science to solve a problem. The engineering process requires the following skills: Written Communication, Oral Communication, Teamwork, Organization, Numeracy, Leadership, Analytical, Flexible, Problem-Solving, Computer and Technical	**Skills (Application):** Identify a problem that can be solved using the engineering practices. Design a research based solution. Communicate justification for the solution while recognizing potential limitations and constraints.

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Benchmarks

Students will be assessed on their *ability* to:

Investigate a needs assessment to determine relative importance of the problem

- Formulate pros and cons of a current problem
- Compare current problem to similar problems
- Investigate possible solutions
- Investigate other options via the Internet, library, interviews, etc.
- Draw conclusions from research by interviewing industry professionals
- Develop a logical design plan, identify, and resolve logic errors
- Formulate a course of action to solve the chosen problem
- Analyze the pros and cons of each solution
- Analyze potential solutions
- Prove and defend the best solution
- Propose solution ideas to team members

Academic Connections

ELA Literacy and/or Math Standard (if applicable, Science and/or Social Studies Standard):	**Sample Performance Task Aligned to the Academic Standard(s):**
Science and Engineering Practices Asking Questions and Defining Problems Developing and Using Models Planning and Carrying out Investigations Analyzing and Interpreting Data Using Mathematical and Computational Thinking Obtaining, Evaluating, and Communicating Information Engaging in Argument from Evidence	**Science and Engineering Practices** Be explicit with students about the Science and Engineering Practices involved in identifying a solution to a problem. Have students reflect on which practices they used.
Engineering and Design Standards 9-12-ETS1-1.Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	**Engineering and Design Standards** Identify a problem that can be solved using the engineering practices. Design a research based solution.

	Communicate justification for the solution while recognizing potential limitations and constraints. **Science** Students may need to research specific scientific concepts for their background information and planning of their solution. For example, if students are designing a solution for moving an object from one place to another, they should understand concepts related to forces, work, power and simple/complex machines. Concepts like friction, energy transfer, and the composition of matter may be useful.
Science Depends on the nature of the problem and science content that may support the solution. http://doe.sd.gov/contentstandards/documents/sdSciStnd.pdf	
Math Practices Make sense of problems and persevere in solving them. Reason abstractly and quantitatively. Construct viable arguments and critique the reasoning of others. Model with mathematics. Use appropriate tools strategically. Attend to precision. Look for and make use of structure. Look for and express regularity in repeated reasoning.	**Math Practices** Be explicit with students about the Math Practices involved in identifying a solution to a problem. Have students reflect on which practices they used.
Math CCSS.MATH.CONTENT.HSS.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	**Math** Students may need to interpret data from prior studies or carry out initial calculations to make decisions about a solution to a problem.

CCSS.MATH.CONTENT.HSS.ID.A.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).	
English Language Arts 11-12.W.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise, 11-12.W.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. 11-12.W.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and over-reliance on any one source and following a standard format for citations.	**English Language Arts** Students may complete an annotated bibliography of sources they used for background research about their topic. Students may write a proposal or report about their proposed solution, providing justification for their proposed design by citing reputable sources. The proposal could also include valuable background information about science concepts that relate to the design solution. Students may do a presentation to their class about their proposed solution. This is an opportunity for feedback, collaboration, group discussion, and revision.
Social Studies 9-12.G.6.3 - Explain the ways technology expands the human capacity to use and modify the physical environment	**Social Studies** Students may include background information about important social/cultural/political/economic factors that informed the design of their solution.

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INDICATOR #EDD 2: **Construct a prototype of the solution to problem**		
SUB-INDICATOR 2.1 (Webb Level: 2 Skill/Concept): Construct a prototype to model solution		
SUB-INDICATOR 2.2 (Webb Level: 4 Extended Thinking): Test prototype for effectiveness		
Knowledge (Factual): Engineering and Science Practices. Reliable sources of information. Engineering is a practice used to solve a problem.	**Understand (Conceptual):** Prototypes and solutions draw upon multiple disciplines including math, science, technology and art. The design solution is limited by constraints such as cost, access to materials, ease of access or utilization, safety or social/political/cultural considerations. The design solution may require multiple revisions and modifications as it is tested. Problem solving skills, perseverance and the ability to analyze data, ask questions and think critically are essential skills.	**Skills (Application):** Design a research based solution. Carry out tests to assess the effectiveness of the solution. Document modifications and subsequent trials that are conducted.

Benchmarks

Students will be assessed on their *ability* to:

- Sketch a prototype of the product
- Show product specifications
- Construct product according to specifications
- Design a product for safety testing
- Identify safety factors in a given product or process
- Collect data on prototype tests
- Analyze the data for prototype effectiveness

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Academic Connections	
ELA Literacy and/or Math Standard (if applicable, Science and/or Social Studies Standard):	**Sample Performance Task Aligned to the Academic Standard(s):**
Science and Engineering Practices Asking Questions and Defining Problems Developing and Using Models Planning and Carrying out Investigations Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information	**Science and Engineering Practices** Be explicit with students about the Science and Engineering Practices involved in designing and testing a solution to a problem. Have students reflect on which practices they used.
Engineering and Design Standards 9-12-ETS1-2.Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	**Engineering and Design Standards** Design a research based solution. Carry out tests to assess the effectiveness of the solution. Document modifications and subsequent trials that are conducted.
Science Depends on the nature of the problem and science content that may support the solution. http://doe.sd.gov/contentstandards/documents/sdSciStnd.pdf	**Science** Students will need to apply specific scientific concepts in the designing and testing of their solution. For example, if students are designing a solution for moving an object from one place to another, they should understand concepts related to forces, work, power and simple/complex machines. Concepts like friction, energy transfer, and the composition of matter may be useful.
Math Practices Make sense of problems and persevere in solving them. Reason abstractly and quantitatively.	**Math Practices** Be explicit with students about the Math Practices involved in designing and testing a solution to a problem. Have students reflect on which practices they used.

Construct viable arguments and critique the reasoning of others. Model with mathematics. Use appropriate tools strategically. Attend to precision. Look for and make use of structure. Look for and express regularity in repeated reasoning.	
Math This will depend on the solution and the type of data being collected. http://doe.sd.gov/contentstandards/documents/math/Math_Standards1.pdf	**Math** Students may need to interpret data from prior studies or carry out initial calculations to make decisions about a solution to a problem. Apply statistical analysis strategies to evaluate the validity and patterns in their data. Use that information to make predictions about the solution and future performance.
English Language Arts 11-12.W.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise, 11-12.W.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.	**English Language Arts** Students may write a report about their proposed solution, including details about variables they controlled for, procedures and design set up, modifications they made, and how they collected data during the testing phase. Students may do a presentation to their class about the outcomes of testing their solution. This is an opportunity for collaboration, feedback and revision.

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INDICATOR #EDD 3: **Analyze test data results for prototype performance**		
SUB-INDICATOR 3.1 (Webb Level: 4 Extended Thinking): Analyze test results		
SUB-INDICATOR 3.2 (Webb Level: 3 Strategic Thinking): Make decisions based on test result data		
SUB-INDICATOR 3.3 (Webb Level: 4 Extended Thinking): Redesign the product to meet performance needs		
Knowledge (Factual): Engineering and Science Practices. Reliable sources of information. Engineering is a practice used to solve a problem.	**Understand (Conceptual):** Test results from a design solution often requires the use of mathematics skills and the ability to represent data graphically. Test results should be analyzed to validate the final design solution. Variables need to be accounted for as well. Justification of a design solution requires accurate data collection and careful analysis.	**Skills (Application):** Analyze test results, carrying out necessary calculations. Create graphs and charts to depict the data. Use statistical principles to analyze the results.

Benchmarks

Students will be assessed on their *ability* to:

- Analyze product performance data
- Chart and graph data
- Synthesize test results
- Assess performance needs
- Critique product improvements
- Design concept models based on data results
- Evaluate and sketch changes made to prototype
- Judge findings of prototype performance
- Apply changes to prototype

Academic Connections

ELA Literacy and/or Math Standard (if applicable, Science and/or Social Studies Standard):	**Sample Performance Task Aligned to the Academic Standard(s):**
Science and Engineering Practices Asking Questions and Defining Problems Developing and Using Models	**Science and Engineering Practices** Be explicit with students about the Science and Engineering Practices involved in analyzing the results from testing a solution. Have students reflect

Analyzing and Interpreting Data Using Mathematical and Computational Thinking Constructing Explanations and Designing Solutions **Engineering and Design Standards** 9-12-ETS1-3. 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. **Science** Depends on the nature of the problem and science content that may support the solution. http://doe.sd.gov/contentstandards/documents/sdSciStnd.pdf **Math Practices** Make sense of problems and persevere in solving them. Reason abstractly and quantitatively. Construct viable arguments and critique the reasoning of others. Model with mathematics.	on which practices they used. **Engineering and Design Standards** Analyze test results, carrying out necessary calculations. Create graphs and charts to depict the data. Use statistical principles to analyze the results. Use or create simulations to model the impact of the proposed solution as a way to evaluate its efficacy or impact. **Science** Students will need to apply specific scientific concepts in the analysis of their test results. For example, students may need to use scientific equations for calculating force, power, work, energy, enthalpy, entropy, atom efficiency, atom economy, pH, acceleration, gas law, population dynamic, diversity indices and concentration. **Math Practices** Be explicit with students about the Math Practices involved in analyzing the results from testing a solution. Have students reflect on which practices they used.

Use appropriate tools strategically. Attend to precision. Look for and make use of structure. Look for and express regularity in repeated reasoning. **Math** Depends on the solution chosen and type of quantitative data selected. http://doe.sd.gov/contentstandards/documents/math/Math_Standards1.pdf In addition, these standards may apply: CCSS.MATH.CONTENT.HSS.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). CCSS.MATH.CONTENT.HSS.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. **English Language Arts** 11-12.W.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.	**Math** Analyze the data, creating graphical representations. Apply various algebraic practices to calculate results such as slope, force, acceleration, population density. Apply statistical analysis strategies to evaluate the validity and patterns in the data. **English Language Arts** Create a summary of the data, reporting in writing how data was collected and what the data says about the solution. Include graphs with proper headings and reference the data in the text. Relate how the data corresponds to prior research or scientific concepts.

INDICATOR #EDD 4: **Communicate solution(s) and the prototype for others**

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SUB-INDICATOR 4.1 (Webb Level: 4 Extended Thinking): Communicate solutions for product		
Knowledge (Factual): Engineering and Science Practices. Reliable sources of information. Engineering is a practice used to solve a problem.	**Understand (Conceptual):** Engineering and Design process involves regular communication with peers, the public and funding agencies to name a few. Communication both in writing and verbally (public speaking) is an essential part of the engineering and design process.	**Skills (Application):** Create a final report about the engineered solution. Include background information, reasoning for the chosen design, steps taken to test the design, relevant data and conclusions. Prepare and give a presentation about the solution that highlights the design process, the testing of the solution and the results.

Benchmarks
Students will be assessed on their *ability* to:

- Create a presentation of the final product for potential clients
- Compose a report for potential clients
- Design final product options to meet client demand based on needs and responses

Academic Connections

ELA Literacy and/or Math Standard (if applicable, Science and/or Social Studies Standard):	**Sample Performance Task Aligned to the Academic Standard(s):**
Science and Engineering Practices Asking Questions and Defining Problems Developing and Using Models Planning and Carrying out Investigations Analyzing and Interpreting Data Using Mathematical and Computational Thinking Constructing Explanations and Designing Solutions	**Science and Engineering Practices** Be explicit with students about the Science and Engineering Practices involved in identifying, testing, analyzing and communicating about a solution to a problem. Have students reflect on which practices they used.

Obtaining, Evaluating, and Communicating Information Engaging in Argument from Evidence **Science** Depends on the nature of the problem and science content that may support the solution. http://doe.sd.gov/contentstandards/documents/sdSciStnd.pdf	**Science** Students will need to communicate specific scientific concepts when they share the results of their engineering/design solutio. For example, if students are designing a solution for moving an object from one place to another, they should understand concepts related to forces, work, power and simple/complex machines. Concepts like friction, energy transfer, and the composition of matter may be useful.
Math Practices Make sense of problems and persevere in solving them. Reason abstractly and quantitatively. Construct viable arguments and critique the reasoning of others. Model with mathematics. Use appropriate tools strategically. Attend to precision. Look for and make use of structure. Look for and express regularity in repeated reasoning.	**Math Practices** Be explicit with students about the Math Practices involved in identifying, testing, analyzing and communicating about a solution to a problem. Have students reflect on which practices they used.
Math CCSS.MATH.CONTENT.HSS.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).	**Math** Provide graphical representations of data and calculations in the formal paper and presentation for the engineering

CCSS.MATH.CONTENT.HSS.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. **English Language Arts** CC.11-12.W.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. 11-12.W.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and over-reliance on any one source and following a standard format for citations. **Social Studies** 9-12.G.6.3 - Explain the ways technology expands the human capacity to use and modify the physical environment.	and design project. Document statistical and mathematic practices that were used to analyze the data. **English Language Arts** Create a final report about the engineered solution. Include background information, reasoning for the chosen design, steps taken to test the design, relevant data and conclusions. Prepare and give a presentation about the solution that highlights the design process, the testing of the solution and the results. **Social Studies** Students may include background information about important social/cultural/political/economic factors that informed the design of their solution.

Additional Resources

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Please list any resources (e.g., websites, teaching guides, etc.) that would help teachers as they plan to teach these new standards.

Disciplinary Core Ideas for Science Education
http://doe.sd.gov/contentstandards/documents/ApxA-DCIP.pdf

Science and Engineering Practices and Cross Cutting Concepts
http://doe.sd.gov/contentstandards/documents/ApxB-SEPc.pdf

Engineering Design Standards
http://doe.sd.gov/contentstandards/documents/ApxCengin.pdf

Engineering and Design Process
https://www.teachengineering.org/k12engineering/designprocess

Engineering and Design Process Template for Students
http://www.crscience.org/pdf/EngineeringGraphics.pdf

Engineering Design Rubric
https://drive.google.com/file/d/0B23HYd76LsIVb3k5Z1kwckdLYnM/view?usp=sharing