SAN LEANDRO UNIFIED SCHOOL DISTRICT
COURSE PROPOSAL: Course of Study
SECTION A. COVER PAGE

1. **Course Title: Intermediate Product Design and Invention**	7. **Action** ▢New Course ▢ Course Revision ▢ Title Change Only
2. Date Submitted:	8. **Grade Level**(s) ▢ 6 ▢9 ▢11 ▢ 7 ▢10 ▢12 ▢ 8
3. Transcript Title/Abbreviation(s)	**9. Prerequisites** (Please list.) ▢ Required ▢ Recommended Introduction to Engineering, Design, and Innovation
4. Transcript Course Code/Course Number :	**10. Seeking Program Distinction?** ▢ YES (Check one below.) ▢NO ▢Honors ▢ AP ▢Other
5. Subject Area College-Preparatory Elective ("g") / Interdisciplinary	11. **Is this a CTE course?** ▢ YES ▢ NO **If YES, complete Section C**
6. **Department** Career Technical Education	12. **Previously approved by UC?** ▢ YES ▢ NO ▢ NA for 6th-8th Year approved Year removed
13. UC ELIGIBILITY **Already eligible?** ▢ NA for 6th-8th ▢**YES** ▢**NO** **a**▢ **b**▢ **c**▢ **d**▢ **e**▢ **f**▢ **g**▢ **Proposing eligibility?**▢ NA for 6th-8th ▢**YES** ▢**NO** **a**▢ **b**▢ **c**▢ **d**▢ **e**▢ **f**▢ **g**▢ Please mark one for approved eligibility or proposed eligibility.	14. **Unit Value/Course Credit/Length of Course** ▢ 0.5 (semester or half-year ▢ 1.0 (one year equivalent) ▢ 2.0 (two-year equivalent) ▢ Other
15. School Contact and Course Developer Name: Eduardo Nava Phone: (510) 877-0947 Email: enava@slusd.us Position: Educator	
	DISTRICT OFFICE USE ONLY **Date approved by Board Curriculum Committee 1/15/19** **Date approved by Board**

Department Chair  16. Approval Signatures: Department Chair Approval Date: 1/10/19 Principal: Principal:	

SECTION B. COURSE CONTENT

17. Course Description

Have you ever wondered how an iPhone was made or your favorite toy from when you were little? In this class, students will learn how to design a product of their choosing from the ground up resulting in the development and creation of a fully functional device (prototype) that includes mechanics, electronics and software. Potential product designs include robots, hand-held electronic devices, smart toys, smart machines (using software and sensors), smart learning devices and general electro-mechanical products. To support the design and creation of these products, students will be taught how to build circuits, program microcontrollers, create CAD files, use traditional and modern building tools (such as 3D printers, CNC (computer numerical controls) laser cutters and CNC routers.) Students will learn the three C's, (Cost, Customers and Competition.) Students will learn R&D (research and development), creative idea generation, principles of design, the use of spreadsheets to cost out a project, how to research the market to analyze the competition and how to identify who the potential customers are (market analysis). Finally, students create a "pitch" for the product that they give to industry professionals in real world setting.

The class is highly collaborative and project based. Students will learn first-hand user centric design. Students learn about the methods of design and problem solving. From there, students learn about the various tools needed to create tools and how to apply the use of the tools back to the design process. This process will include individual work as well as group work collaboration. The class is designed with real world projects that provide students with the skill set needed to complete product design from initial creativity to CAD models, to electronics, to woodshop, to 3D printing and laser cutting. The class provides students with experiences throughout in a cycle of design, tools and application. Throughout the course students will build on basics science skills to include basic physics mechanics, power, energy, electricity and magnetism that are components of physics as well as math skills daily in terms of problem solving, calculations, logic as they relate to programming and designing. Students using persuasive writing throughout the course as they prepare presentations and regularly does research in preparing kick start presentations at the beginning of each project.

18. Course Goals and/or Major Student Outcomes

- **Learn to see how problems serve as opportunities to create things that improve their world.**
- **User Centric Design- Understand the principles of how to target the design of a product for a specific user or group and learn to target how it is used in society.**
- **Become informed consumers of products who understand the process and economics of bringing a product to market.**
- **Demonstrate an understanding of how the creative process works (as it pertains to product design).**
- **Engage in a constructive (additive) design process where the emphasis is upon finding opportunities to solve problems and not in tearing down designs.**
- **Collaborate in groups, design teams and as a class.**
- **Learn how to problem solve solutions to create, improve, and troubleshoot designs.**
- **Demonstrate an understanding of the iterative process in the conceptual design phase of the project, individually and in groups as they look for many possible solutions to perceived design problems.**
- **Develop problem solving skills including the principle their first instinct is not necessarily the best design solution.**
- **Demonstrate an introductory knowledge of modern communication tools including collaborative (shared) documentation (multiple users working on the same word processing, presentation and spreadsheet).**
- **Demonstrate an introductory knowledge of using CAD software to design dimensionally accurate models of existing objects.**
- **Demonstrate an ability to use CAD software to explore design possibilities.**
- **Demonstrate the ability to build simple electronic circuits using resistors, diodes, batteries, motors, switches and MOSFETS.**
- **Learn how to debug simple routines to be uploaded to microprocessors.**
- **Demonstrate the skills necessary to work in a shop environment that includes traditional shop tools in addition to modern prototyping tools such as 3D printers, CNC routers and CNC laser cutters.**
- **Produce documents that describe their product.**
- **Create marketing plans in both traditional forms and more recent "crowd-sourcing" techniques (such as Kickstarter).**

19. Course Objectives (standards)

See Exhibit A

https://www.cde.ca.gov/ci/ct/sf/documents/manproddev.pdf

CTE Pathway: Product Innovation and Design Pathway

Product Innovation and Design Pathway
The Product Innovation and Design pathway provides students with an understanding of the design and manufacturing technologies common to careers in the fields of product design and manufacturing. Representative topics include the product design and development process, the principles of design, computer aided design, fabrication and manufacturing processes, sustainability, and the principles of business, entrepreneurship, and global design

D1.0 Understand the basic product design and development process as it relates to the design of a product, line of products, system design, or services.
D1.1 Identify the variations in the product design and development process as it relates to the designing of a product, product line, system design, or service.
D1.2 Apply and identify the various phases of the product design development process to an existing product, product line, system design, or service.
D2.0 Understand and apply research methodologies as a means to identify a need, problem, or opportunity for a new product, product line, system design, or service.

D2.1 Employ research methodologies, using primary research and electronic reference materials, to gather information relevant to the topic or area of opportunity.
D2.2 Organize information to identify and define an area of opportunity, need, or problem that can be resolved through design.
D2.3 Identify potential design areas (e.g., product, product line, system design, or service) that would address the need, problem, or opportunity.
D2.4 Research and identify the user demographic for the product, product line, system design, or service (local, national, global market).
D3.0 Understand and apply various ideation techniques to develop ideas and concepts.
D3.1 Apply ideation techniques to explore and produce multiple concepts.
D3.2 Edit concepts and identify key idea(s) that solve the problem, fulfill a need, or address an opportunity.
D3.3 Assess the environmental impact of the design solution and other sustainability issues and product life cycle considerations.
D3.4 Synthesize information and experiment with nontraditional possibilities for innovative design solutions.
Manufacturing and Product Development | MPD
D4.0 Apply various two-dimensional (2-D) graphic and/or three-dimensional (3-D) modeling techniques to development concept.
D4.1 Create a preliminary design of a product concept utilizing drawing, computer software (graphic or CAD), and/or conceptual model fabrication techniques.
D4.2 Identify materials, mechanisms, technologies, and other requirements (e.g., safety, manufacturing, sustainability) the concept may require.
D4.3 Analyze and assess the strengths and weaknesses in the design, function, ergonomics, features, and benefits and identify possible resolutions for improvement.
D5.0 Develop the concept into a well-defined product for prototyping.
D5.1 Produce technical drawings and other specifications required for the prototyping or manufacturing of the product.
D5.2 Recognize the safety issues related to the reliability, functionality, and use of the product.
D5.3 Communicate and collaborate with fabricators, manufacturers, engineers, technologists, or other industry experts to review requirements and specifications and to validate the design.

20. Course Outline

See Exhibit B

21. Instructional Materials:

Board approved required text

Supplementary materials

AutoDesk CAD Software, AutoDesk INC, students.autodesk.com

Title: What I Wish I Knew When I Was 20
Edition: 1st
Publication Date: 2009
Publisher: HarperOne
Author(s): Mary Seelig

Title: Conceptual Physics
Edition: 11th
Publication Date: 2011
Publisher: Addison-Wesley
Author(s): Paul G. Hewitt

Title: Inspired: How to Create Products Customers Love
Edition: 1st
Publication Date: 2008
Publisher: SVPG Press
Author(s): Marty Cagan

22. Instructional Methods and/or Strategies (Key Assignments)

1) The Design Process , Shop Safety, and Energy (3D Ring Project)
2) Tools and Materials for Designing Products (Concept Generation Project and Report)
3) Working Collaboratively to Create Structures (Structure Project)
4) Modifying Existing Products and Understanding Control Systems. (Hack A Toy Project)
5) Marketing and Statistics (Decolonize Project and Report)
6) Creatively Solving with Meaning and Purpose. (Softgood Project and report)
7)Culminating Project and Fluid Power (Origami Project)
8) Prototype of Functional Concept and Kinematics (Functional Project)

23. Assessment Methods and/or Tools

Grades will be calculated on a straight point basis. Projects will be based on a scale of 1 to 100 points depending on the assignment or project. Daily work and participation grades will be based on completion of the Engineering Notebook and Portfolio. Weekly quizzes, cumulative unit exams and a National PLTW Assessment will be given during the semester. All students must maintain an Engineering Notebook and Portfolio to pass the class. They will be checked periodically throughout semester.

24. Grading Policy

Grading will follow the San Leandro Unified School District's policy.
All grades letter and percentage will be as follows:

100+ - 89% / Excellent

88 - 79% / Above Average
78 - 69% / Average
68 - 60%/ Below Average
Below 60%/ Failure
Grading is weighted as follows:
Class Participation & Professionalism 30%
Project Assignments 60%
Project Book 10%

SECTION C

25. Context for Course (optional)

REQUIRED FOR CTE COURSES

NOTE: In order to understand the context for a new course, sometimes it is helpful to understand the broader educational program and/or reform efforts of the school. How does this course fit into broader departmental and/or pathway structure? How does it fit into the overall school restructuring plans? Is the course intended to be a core course or supplemental? What are the student/school/community needs met by this course?

We are revising our Advanced Manufacturing and Engineering program and creating a Product Development Pathway. This course is designed to create a student centered learning environment where students can take ownership of their projects and a learn by doing model. This course fits well with the Project based learning strategy implemented in our district. This is a core course in the Product Development pathway and a prerequisite for the capstone course.

This course gives students exposure to entrepreneurial and technological practices that are disrupting local business practices. Giving our students and community the most uptodate practices.

26. History of Course Development (optional)

REQUIRED FOR CTE COURSES

NOTE: Likewise, it is sometimes helpful know the origins of a course and who was involved in its development. Was this course modeled after another course at another school? If so, is that course UC approved? How does the course being submitted differ from the course after which it was modeled? Has this course received any special recognitions, designations or awards? Has it been articulated to local community colleges or universities?

This course was modeled after the Product Design 1 course at Novato High School, California. That course is UC approved. It was slightly modified to generalize the software utilized and to encompass the PLTW Principles of Engineering Course.

Exhibit A

Course Objectives (Standards):

Principles of Engineering (PoE)

Common Core State Standards for English Language Arts

Lesson 2.2

AS.R.1 - Reading

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 - Reading

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. AS.R.9 - Reading

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take. AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently. AS.W.2 - Writing

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.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. AS.W.7 - Writing

Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. AS.W.8 - Writing

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

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AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research. AS.W.10 - Writing

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 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. AS.SL.4 - Speaking and Listening

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 - Speaking and Listening

Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations. AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. AS.L.6 - Language

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.

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Principles of Engineering (PoE)

Common Core State Standards for English Language Arts

Lesson 4.2

AS.W.5 - Writing

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. AS.W.7 - Writing

Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. AS.W.8 - Writing

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 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research. AS.W.10 - Writing

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 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

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AS.L.6 - Language

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.

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Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 1.1

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling. N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context. A.SSE.1.a - Seeing Structure in Expressions

Interpret parts of an expression, such as terms, factors, and coefficients. A.SSE.1.b - Seeing Structure in Expressions

Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+r)n as the product of P and a factor not depending on P. A.CED.1 - Creating Equations

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. A.CED.4 - Creating Equations

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. A.REI.3 - Reasoning with Equations and Inequalities

Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

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F.LE.1.b - Linear, Quadratic, and Exponential Models

Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. G.MG.1 - Modeling with Geometry

Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). G.MG.3 - Modeling with Geometry

Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

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Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 1.4

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling. N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 2.2

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. G.GMD.3 - Geometric Measurement and Dimension

Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems. G.GMD.4 - Geometric Measurement and Dimension

Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two- dimensional objects. G.MG.1 - Modeling with Geometry

Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder). G.MG.2 - Modeling with Geometry

Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).

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Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 2.3

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling. N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context. A.SSE.1.a - Seeing Structure in Expressions

Interpret parts of an expression, such as terms, factors, and coefficients. A.SSE.1.b - Seeing Structure in Expressions

Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+r)n as the product of P and a factor not depending on P.

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Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 2.4

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

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Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 3.3

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 4.1

S.ID.1 - Interpreting Categorical and Quantitative Data

Represent data with plots on the real number line (dot plots, histograms, and box plots). S.ID.2 - Interpreting Categorical and Quantitative Data

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. S.ID.3 - Interpreting Categorical and Quantitative Data

Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). S.ID.4 - Interpreting Categorical and Quantitative Data

Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. S.IC.1 - Making Inferences and Justifying Conclusions

Understand statistics as a process for making inferences about population parameters based on a random sample from that population. S.IC.2 - Making Inferences and Justifying Conclusions

Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model? S.IC.4 - Making Inferences and Justifying Conclusions

Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling. S.CP.1 - Conditional Probability and the Rules of Probability

Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events (“or,” “and,” “not”). S.CP.2 - Conditional Probability and the Rules of Probability

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Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent. S.CP.3 - Conditional Probability and the Rules of Probability

Understand the conditional probability of A given B as P(A and B)/P(B), and interpret independence of A and B as saying that the conditional probability of A given B is the same as the probability of A, and the conditional probability of B given A is the same as the probability of B. S.CP.4 - Conditional Probability and the Rules of Probability

Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. For example, collect data from a random sample of students in your school on their favorite subject among math, science, and English. Estimate the probability that a randomly selected student from your school will favor science given that the student is in tenth grade. Do the same for other subjects and compare the results. S.CP.5 - Conditional Probability and the Rules of Probability

Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. For example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer. S.CP.6 - Conditional Probability and the Rules of Probability

Find the conditional probability of A given B as the fraction of B's outcomes that also belong to A, and interpret the answer in terms of the model. S.CP.7 - Conditional Probability and the Rules of Probability

Apply the Addition Rule, P(A or B) = P(A) + P(B) – P(A and B), and interpret the answer in terms of the model. S.CP.8 - Conditional Probability and the Rules of Probability

(+) Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model. S.CP.9 - Conditional Probability and the Rules of Probability

(+) Use permutations and combinations to compute probabilities of compound events and solve problems. S.MD.7 - Using Probability to Make Decisions

(+) Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Common Core State Standards for Mathematics

Lesson 4.2

N.RN.2 - The Real Number System

Rewrite expressions involving radicals and rational exponents using the properties of exponents. N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling. N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. N.VM.1 - Vector and Matrix Quantities

(+) 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 (e.g., v, |v|, ||v||, v). N.VM.2 - Vector and Matrix Quantities

(+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. N.VM.3 - Vector and Matrix Quantities

(+) Solve problems involving velocity and other quantities that can be represented by vectors. A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context. A.SSE.1.a - Seeing Structure in Expressions

Interpret parts of an expression, such as terms, factors, and coefficients. A.SSE.1.b - Seeing Structure in Expressions

Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+r)n as the product of P and a factor not depending on P.

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A.CED.3 - Creating Equations

Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non- viable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods. A.CED.4 - Creating Equations

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. A.REI.3 - Reasoning with Equations and Inequalities

Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. A.REI.4 - Reasoning with Equations and Inequalities

Solve quadratic equations in one variable. F.TF.7 - Trigonometric Functions

(+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context. G.SRT.6 - Similarity, Right Triangles, and Trigonometry

Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles. G.SRT.8 - Similarity, Right Triangles, and Trigonometry

Use trigonometric ratios and the Pythagorean theorem to solve right triangles in applied problems. G.MG.3 - Modeling with Geometry

Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios). S.ID.2 - Interpreting Categorical and Quantitative Data

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.

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Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 1.1

DCI - PS3.A - Energy - Definitions of Energy

At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2), (HS-PS3-3) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Conserv ation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

The availability of energy limits what can occur in any system. (HS-PS3-1) DCI - PS3.D - Energy - Energy in Chemical Processes and Everyday Life

Although energy cannot be destroyed, it can be converted to less useful forms— for example, to thermal energy in the surrounding environment. (HS-PS3-3), (HS-PS3-4) Science and Engineering Practice - Analyzing and Interpreting Data

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

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PLTW Standards and Alignment

Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Changes in systems may have various causes that may not have equal effects. Crosscutting Concepts - Systems and System Models

Systems can be designed to do specific tasks.

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PLTW Standards and Alignment

Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation The total amount of energy and matter in closed systems is conserved. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 1.2

HS.PS3.3 - Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS.PS3.4 - Energy

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). HS.ESS3.1 - Earth and Human Activity

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. HS.ESS3.2 - Earth and Human Activity

Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. HS.ESS3.4 - Earth and Human Activity

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS.ETS1.1 - Engineering Design

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. DCI - PS3.A - Energy - Definitions of Energy

“Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) DCI - PS3.A - Energy - Definitions of Energy

Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1), (HS-PS3-2) DCI - PS3.A - Energy - Definitions of Energy

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PLTW Standards and Alignment

At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2), (HS-PS3-3) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Conserv ation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between sy stems. (HS-PS3-1), (HS-PS3-4) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

The availability of energy limits what can occur in any system. (HS-PS3-1) DCI - PS3.D - Energy - Energy in Chemical Processes and Everyday Life

Although energy cannot be destroyed, it can be converted to less useful forms— for example, to thermal energy in the surrounding environment. (HS-PS3-3), (HS-PS3-4) DCI - PS3.D - Energy - Energy in Chemical Processes and Everyday Life

Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. (secondary to HS-PS4-5) DCI - PS3.D - Energy - Energy in Chemical Processes and Everyday Life

The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5) DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) DCI - ETS1.B - Engineering Design - Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) DCI - ETS1.C - Engineering Design - Optimizing the Design Solution

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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 (tradeoffs) may be needed. (secondary to HS-PS1-6) DCI - ESS3.A - Earth and Human Activity - Natural Resources

Resource availability has guided the development of human society. (HS-ESS3-1) DCI - ESS3.A - Earth and Human Activity - Natural Resources

All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) DCI - ESS3.C - Earth and Human Activity - Human Impacts on Earth Systems

Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosy stem degradation. (HS-ESS3-4) DCI - ESS3.D - Earth and Human Activity - Global Climate Change

Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Science and Engineering Practice - Developing and Using Models

Design a test of a model to ascertain its reliability. Science and Engineering Practice - Developing and Using Models

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Science and Engineering Practice - Developing and Using Models

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system. Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems.

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PLTW Standards and Alignment

Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. Science and Engineering Practice - Planning and Carrying Out Investigations

Select appropriate tools to collect, record, analyze, and evaluate data. Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

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Systems can be designed to cause a desired effect. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Changes in systems may have various causes that may not have equal effects. Crosscutting Concepts - Systems and System Models

Systems can be designed to do specific tasks. Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. Crosscutting Concepts - Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Tracking energy and matter flows, into, out of, and within systems helps one understand their system’s behavior. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation The total amount of energy and matter in closed systems is conserved. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

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PLTW Standards and Alignment

Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Energy drives the cycling of matter within and between systems. Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 1.3

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Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. DCI - PS3.A - Energy - Definitions of Energy

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PLTW Standards and Alignment

At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2), (HS-PS3-3)

DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Conserv ation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between sy stems. (HS-PS3-1), (HS-PS3-4) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) DCI - PS3.B - Energy - Conservation of Energy and Energy Transfer

The availability of energy limits what can occur in any system. (HS-PS3-1) DCI - PS3.D - Energy - Energy in Chemical Processes and Everyday Life

Although energy cannot be destroyed, it can be converted to less useful forms— for example, to thermal energy in the surrounding environment. (HS-PS3-3), (HS-PS3-4) DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

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When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) DCI - ETS1.C - Engineering Design - Optimizing the Design Solution

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 (tradeoffs) may be needed. (secondary to HS-PS1-6)

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DCI - ESS3.C - Earth and Human Activity - Human Impacts on Earth Systems

Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosy stem degradation. (HS-ESS3-4) DCI - ESS3.D - Earth and Human Activity - Global Climate Change

Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Science and Engineering Practice - Developing and Using Models

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 1.4

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Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS.ESS3.4 - Earth and Human Activity

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS.ETS1.1 - Engineering Design

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. HS.ETS1.2 - Engineering Design

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS.ETS1.3 - Engineering Design

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.ETS1.4 - Engineering Design

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. DCI - PS3.A - Energy - Definitions of Energy

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PLTW Standards and Alignment

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Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Science and Engineering Practice - Asking questions and defining problems

Ask questions

o that arise from careful observation of phenomena, or unexpected results, to

clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek

additional information and relationships. o to determine relationships, including quantitative relationships, between

independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. Science and Engineering Practice - Asking questions and defining problems Evaluate a question to determine if it is testable and relevant. Science and Engineering Practice - Asking questions and defining problems

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Science and Engineering Practice - Asking questions and defining problems

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. Science and Engineering Practice - Asking questions and defining problems

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations. Science and Engineering Practice - Developing and Using Models

Design a test of a model to ascertain its reliability. Science and Engineering Practice - Developing and Using Models

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Science and Engineering Practice - Developing and Using Models

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Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Constructing Explanations and Designing Solutions Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

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Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Empirical evidence is needed to identify patterns. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Changes in systems may have various causes that may not have equal effects. Crosscutting Concepts - Systems and System Models

Systems can be designed to do specific tasks. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

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Tracking energy and matter flows, into, out of, and within systems helps one understand their system’s behavior. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation The total amount of energy and matter in closed systems is conserved. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Crosscutting Concepts - Energy and Matter: Flows, Cycles, and Conservation

Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 2.1

Science and Engineering Practice - Asking questions and defining problems

Ask questions

o that arise from careful observation of phenomena, or unexpected results, to

clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek

additional information and relationships. o to determine relationships, including quantitative relationships, between

independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. Science and Engineering Practice - Asking questions and defining problems Evaluate a question to determine if it is testable and relevant. Science and Engineering Practice - Asking questions and defining problems

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions

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Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

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Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect. Crosscutting Concepts - Scale, Proportion, and Quantity

The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Crosscutting Concepts - Scale, Proportion, and Quantity

Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Crosscutting Concepts - Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). Crosscutting Concepts - Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. Crosscutting Concepts - Systems and System Models

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Systems can be designed to do specific tasks. Crosscutting Concepts - Systems and System Models

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Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. Crosscutting Concepts - Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Crosscutting Concepts - Structure and Function

The way an object is shaped or structured determines many of its properties and functions. Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. Crosscutting Concepts - Structure and Function

The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. Crosscutting Concepts - Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. Crosscutting Concepts - Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. Crosscutting Concepts - Stability and Change

Feedback (negative or positive) can stabilize or destabilize a system. Crosscutting Concepts - Stability and Change

Systems can be designed for greater or lesser stability.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 2.2

HS.PS1.1 - Matter and Its Interactions

Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. DCI - PS1.A - Matter and Its Interactions - Structure and Properties of Matter

The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) DCI - PS1.A - Matter and Its Interactions - Structure and Properties of Matter

The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), (secondary to HS-PS2-6) Science and Engineering Practice - Asking questions and defining problems

Ask questions

o that arise from careful observation of phenomena, or unexpected results, to

clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek

additional information and relationships. o to determine relationships, including quantitative relationships, between

independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. Science and Engineering Practice - Asking questions and defining problems Evaluate a question to determine if it is testable and relevant. Science and Engineering Practice - Asking questions and defining problems

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

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Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

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Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect. Crosscutting Concepts - Scale, Proportion, and Quantity

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PLTW Standards and Alignment

The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Crosscutting Concepts - Scale, Proportion, and Quantity

Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Crosscutting Concepts - Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). Crosscutting Concepts - Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. Crosscutting Concepts - Systems and System Models

Systems can be designed to do specific tasks. Crosscutting Concepts - Systems and System Models

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. Crosscutting Concepts - Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Crosscutting Concepts - Structure and Function

The way an object is shaped or structured determines many of its properties and functions. Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. Crosscutting Concepts - Structure and Function

The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Crosscutting Concepts - Stability and Change

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For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. Crosscutting Concepts - Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. Crosscutting Concepts - Stability and Change

Feedback (negative or positive) can stabilize or destabilize a system. Crosscutting Concepts - Stability and Change

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 2.3

HS.PS1.3 - Matter and Its Interactions

Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. DCI - PS1.A - Matter and Its Interactions - Structure and Properties of Matter

The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), (secondary to HS-PS2-6) Science and Engineering Practice - Asking questions and defining problems

Ask questions

o that arise from careful observation of phenomena, or unexpected results, to

clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek

additional information and relationships. o to determine relationships, including quantitative relationships, between

independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. Science and Engineering Practice - Asking questions and defining problems Evaluate a question to determine if it is testable and relevant. Science and Engineering Practice - Asking questions and defining problems

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

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PLTW Standards and Alignment

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

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Crosscutting Concepts - Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. Crosscutting Concepts - Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Crosscutting Concepts - Patterns

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Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. Crosscutting Concepts - Patterns

Mathematical representations are needed to identify some patterns. Crosscutting Concepts - Patterns

Empirical evidence is needed to identify patterns. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect. Crosscutting Concepts - Scale, Proportion, and Quantity

The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Crosscutting Concepts - Scale, Proportion, and Quantity

Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Crosscutting Concepts - Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). Crosscutting Concepts - Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. Crosscutting Concepts - Systems and System Models

Systems can be designed to do specific tasks. Crosscutting Concepts - Systems and System Models

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. Crosscutting Concepts - Systems and System Models

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Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Crosscutting Concepts - Structure and Function

The way an object is shaped or structured determines many of its properties and functions. Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. Crosscutting Concepts - Structure and Function

The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. Crosscutting Concepts - Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. Crosscutting Concepts - Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. Crosscutting Concepts - Stability and Change

Feedback (negative or positive) can stabilize or destabilize a system. Crosscutting Concepts - Stability and Change

Systems can be designed for greater or lesser stability.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 2.4

HS.ESS3.4 - Earth and Human Activity

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS.ETS1.2 - Engineering Design

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS.ETS1.3 - Engineering Design

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.ETS1.4 - Engineering Design

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. DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) DCI - ETS1.B - Engineering Design - Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) DCI - ETS1.C - Engineering Design - Optimizing the Design Solution

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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. (secondary to HS-PS1-6) Science and Engineering Practice - Asking questions and defining problems

Ask questions

o that arise from careful observation of phenomena, or unexpected results, to

clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek

additional information and relationships. o to determine relationships, including quantitative relationships, between

independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. Science and Engineering Practice - Asking questions and defining problems Evaluate a question to determine if it is testable and relevant. Science and Engineering Practice - Asking questions and defining problems

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. Science and Engineering Practice - Planning and Carrying Out Investigations

Select appropriate tools to collect, record, analyze, and evaluate data. Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Science and Engineering Practice - Using Mathematics and Computational Thinking

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Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Science and Engineering Practice - Using Mathematics and Computational Thinking

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Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Engaging in Argument from Evidence

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Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

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PLTW Standards and Alignment

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Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Crosscutting Concepts - Scale, Proportion, and Quantity

Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. Crosscutting Concepts - Scale, Proportion, and Quantity

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 3.1

Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

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Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

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PLTW Standards and Alignment

Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

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Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 3.2

HS.PS3.3 - Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS.ETS1.3 - Engineering Design

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 and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

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PLTW Standards and Alignment

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Science and Engineering Practice Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 3.3

HS.PS3.3 - Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS.ETS1.2 - Engineering Design

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS.ETS1.3 - Engineering Design

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.ETS1.4 - Engineering Design

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. DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) DCI - ETS1.B - Engineering Design - Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) DCI - ETS1.C - Engineering Design - Optimizing the Design Solution

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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 (tradeoffs) may be needed. (secondary to HS-PS1-6) Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Constructing Explanations and Designing Solutions Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations). Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

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PLTW Standards and Alignment

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 4.1

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

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PLTW Standards and Alignment

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Next Generation Science Standards

Lesson 4.2

HS.PS2.1 - Motion and Stability: Forces and Interactions

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. HS.PS3.3 - Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. DCI - ETS1.A - Engineering Design - Defining and Delimiting Engineering Problems

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) DCI - ETS1.B - Engineering Design - Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) DCI - ETS1.C - Engineering Design - Optimizing the Design Solution

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 (tradeoffs) may be needed. (secondary to HS-PS1-6) Science and Engineering Practice - Asking questions and defining problems

Ask questions

o that arise from careful observation of phenomena, or unexpected results, to

clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek

additional information and relationships. o to determine relationships, including quantitative relationships, between

independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. Science and Engineering Practice - Asking questions and defining problems Evaluate a question to determine if it is testable and relevant.

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PLTW Standards and Alignment

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Science and Engineering Practice - Using Mathematics and Computational Thinking

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Science and Engineering Practice - Using Mathematics and Computational Thinking

Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Science and Engineering Practice - Using Mathematics and Computational Thinking Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.). Science and Engineering Practice - Constructing Explanations and Designing Solutions Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Science and Engineering Practice - Constructing Explanations and Designing Solutions Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Science and Engineering Practice - Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student- generated evidence.

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PLTW Standards and Alignment

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Crosscutting Concepts - Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). Crosscutting Concepts - Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 1.1

12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 16.9-12.L Students will develop an understanding of and be able to select and use energy and power technologies.

L. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. 16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

N. Power systems must have a source of energy, a process, and loads. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 1.2

4.9-12.I Students will develop an understanding of the cultural, social, economic, and political effects of technology.

I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. 4.9-12.J Students will develop an understanding of the cultural, social, economic, and political effects of technology.

J. Ethical considerations are important in the development, selection, and use of technologies. 4.9-12.K Students will develop an understanding of the cultural, social, economic, and political effects of technology.

K. The transfer of a technology from one society to another can cause cultural, social,economic, and political changes affecting both societies to varying degrees. 5.9-12.G Students will develop an understanding of the cultural, social, economic, and political effects of technology.

G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. 5.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. 5.9-12.I Students will develop an understanding of the cultural, social, economic, and political effects of technology.

I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. 5.9-12.J Students will develop an understanding of the cultural, social, economic, and political effects of technology.

J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. 5.9-12.K Students will develop an understanding of the cultural, social, economic, and political effects of technology.

K. Humans devise technologies to reduce the negative consequences of other technologies.

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PLTW Standards and Alignment

5.9-12.L Students will develop an understanding of the cultural, social, economic, and political effects of technology.

L. Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 16.9-12.J Students will develop an understanding of and be able to select and use energy and power technologies.

J. Energy cannot be created nor destroyed; however, it can be converted from one form to another. 16.9-12.K Students will develop an understanding of and be able to select and use energy and power technologies.

K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical,chemical, nuclear, and others. 16.9-12.L Students will develop an understanding of and be able to select and use energy and power technologies.

L. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. 16.9-12.M Students will develop an understanding of and be able to select and use energy and power technologies.

M. Energy resources can be renewable or nonrenewable. 16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

N. Power systems must have a source of energy, a process, and loads. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 1.3

4.9-12.I Students will develop an understanding of the cultural, social, economic, and political effects of technology.

I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. 4.9-12.J Students will develop an understanding of the cultural, social, economic, and political effects of technology.

J. Ethical considerations are important in the development, selection, and use of technologies. 4.9-12.K Students will develop an understanding of the cultural, social, economic, and political effects of technology.

K. The transfer of a technology from one society to another can cause cultural, social,economic, and political changes affecting both societies to varying degrees. 5.9-12.G Students will develop an understanding of the cultural, social, economic, and political effects of technology.

G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. 5.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. 5.9-12.I Students will develop an understanding of the cultural, social, economic, and political effects of technology.

I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. 5.9-12.J Students will develop an understanding of the cultural, social, economic, and political effects of technology.

J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. 5.9-12.K Students will develop an understanding of the cultural, social, economic, and political effects of technology.

K. Humans devise technologies to reduce the negative consequences of other technologies.

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5.9-12.L Students will develop an understanding of the cultural, social, economic, and political effects of technology.

L. Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 16.9-12.J Students will develop an understanding of and be able to select and use energy and power technologies.

J. Energy cannot be created nor destroyed; however, it can be converted from one form to another. 16.9-12.K Students will develop an understanding of and be able to select and use energy and power technologies.

K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. 16.9-12.L Students will develop an understanding of and be able to select and use energy and power technologies.

L. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. 16.9-12.M Students will develop an understanding of and be able to select and use energy and power technologies.

M. Energy resources can be renewable or nonrenewable. 16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

N. Power systems must have a source of energy, a process, and loads. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 1.4

2.9-12.Z Students will develop an understanding of the core concepts of technology. Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. 8.9-12.H Students will develop an understanding of the attributes of design.

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype. 8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form. 8.9-12.J Students will develop an understanding of the attributes of design.

J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. 8.9-12.K Students will develop an understanding of the attributes of design.

K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. 9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. 9.9-12.J Students will develop an understanding of engineering design.

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. 9.9-12.K Students will develop an understanding of engineering design.

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. 9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors. 11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it. 11.9-12.N Students will develop the abilities to apply the design process.

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PLTW Standards and Alignment

N. Identify criteria and constraints and determine how these will affect the design process. 11.9-12.O Students will develop the abilities to apply the design process.

O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. 11.9-12.P Students will develop the abilities to apply the design process.

P. Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. 11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process. 11.9-12.R Students will develop the abilities to apply the design process.

R. Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. 12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

N. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. 12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 16.9-12.J Students will develop an understanding of and be able to select and use energy and power technologies.

J. Energy cannot be created nor destroyed; however, it can be converted from one form to another.

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16.9-12.K Students will develop an understanding of and be able to select and use energy and power technologies.

K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical,chemical, nuclear, and others. 16.9-12.L Students will develop an understanding of and be able to select and use energy and power technologies.

L. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings. 16.9-12.M Students will develop an understanding of and be able to select and use energy and power technologies.

M. Energy resources can be renewable or nonrenewable. 16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

N. Power systems must have a source of energy, a process, and loads. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 2.1

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 2.2

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 2.3

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

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Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 2.4

2.9-12.W Students will develop an understanding of the core concepts of technology.

W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. 2.9-12.X Students will develop an understanding of the core concepts of technology.

X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. 2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. 2.9-12.Z Students will develop an understanding of the core concepts of technology..

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. 2.9-12.AA Students will develop an understanding of the core concepts of technology. AA. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. 8.9-12.H Students will develop an understanding of the attributes of design.

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype. 8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form. 8.9-12.J Students will develop an understanding of the attributes of design.

J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. 8.9-12.K Students will develop an understanding of the attributes of design.

K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. 9.9-12.I Students will develop an understanding of engineering design.

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I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. 9.9-12.J Students will develop an understanding of engineering design.

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. 9.9-12.K Students will develop an understanding of engineering design.

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. 9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors. 11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it. 11.9-12.N Students will develop the abilities to apply the design process.

N. Identify criteria and constraints and determine how these will affect the design process. 11.9-12.O Students will develop the abilities to apply the design process.

O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. 11.9-12.P Students will develop the abilities to apply the design process.

P. Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. 11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process. 11.9-12.R Students will develop the abilities to apply the design process.

R. Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

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12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

N. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. 12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. 17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 3.1

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 3.2

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information. 12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 3.3

2.9-12.W Students will develop an understanding of the core concepts of technology.

W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. 2.9-12.X Students will develop an understanding of the core concepts of technology.

X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. 2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. 2.9-12.Z Students will develop an understanding of the core concepts of technology. Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. 2.9-12.AA Students will develop an understanding of the core concepts of technology. AA. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. 2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information. 8.9-12.H Students will develop an understanding of the attributes of design.

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype. 8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form. 8.9-12.J Students will develop an understanding of the attributes of design.

J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. 8.9-12.K Students will develop an understanding of the attributes of design.

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K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. 9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. 9.9-12.J Students will develop an understanding of engineering design.

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. 9.9-12.K Students will develop an understanding of engineering design.

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. 9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors. 10.9-12.I Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

I. Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. 10.9-12.J Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

J. Technological problems must be researched before they can be solved. 10.9-12.K Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

K. Not all problems are technological, and not every problem can be solved using technology. 10.9-12.L Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

L. Many technological problems require a multidisciplinary approach. 11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it. 11.9-12.N Students will develop the abilities to apply the design process.

N. Identify criteria and constraints and determine how these will affect the design process. 11.9-12.O Students will develop the abilities to apply the design process.

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O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. 11.9-12.P Students will develop the abilities to apply the design process.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 4.1

12.9-12.L Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. 12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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PLTW Standards and Alignment

Principles of Engineering (PoE)

Standards for Technological Literacy

Lesson 4.2

8.9-12.H Students will develop an understanding of the attributes of design.

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype. 8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form. 8.9-12.J Students will develop an understanding of the attributes of design.

J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. 8.9-12.K Students will develop an understanding of the attributes of design.

K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. 9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. 9.9-12.J Students will develop an understanding of engineering design.

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. 9.9-12.K Students will develop an understanding of engineering design.

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Exhibit B

Course Outline:

Unit 1: The Design Process , Shop Safety, and Energy (3D Ring)

Students get a general introduction to the user centric design process. They learn numerous brainstorming techniques, research methodologies, looking for opportunities, understanding the customer

Students learn to use CAD (Computer Aided Design) programs and will create their own design of a 3D printed product

Students learn about shop hazards and safety procedures. Students will learn correct procedures to work in the shop safely and efficiently. They will also demonstrate proven methods of shop procedures.

Students will be introduced to mechanisms, energy sources, and alternative energy applications. Students will gain an understanding of mechanisms through the application of theory based calculations accompanied by lab experimentation.

Unit 2: Tools and Materials for Designing Products (Shoe)

Students are introduced to beginning electronics in preparation for creating electronic prototypes. Students learn the skills about creating a product, modifying a product, creating basic shapes including oval and corkscrew using CAD tools. This provides students with the skills they will need to create design in the future. Students learn basic skills, and demonstrate knowledge of skills through creating items. Once students have learned to use CAD, they add electronic components.

Students build and analyze, using a digital voltmeter, simple circuits composed of resistors, LEDs, diodes, batteries, capacitors and MOSFETS. Students demonstrate their knowledge through traditional tests and circuit board problem solving.

Students learn about material properties, which lead students to the ability to properly select a material for a given task. Creating new products to meet a given need or want is not the only concern in this area of study. How to reuse/ recycle materials for continued and unique uses is also learned.

Unit 3: Working Collaboratively to Create Structures (Dome)

Students learn to use social media and team collaboration software to plan and produce a large collaborative, student created project.
Students design their machines in CAD with accurate dimensions and then produce their designs in the technology shop.
Throughout the project, students learn to use technology through social media including shared documents, communicating with the members of their groups, deadlines, sharing of information and how to communicate well throughout all phases of the project.
Group Project: Collaborative, as a class, design and build a LIFE-SIZED structures. Students assemble all the components and put their structure to the test. Students produce a video of the final test.

Students will have a more concrete understanding of material properties and statics. Students begin by learning about beam deflection and the forces on truss structures. They learn to identify forces acting on those structures and then gain the ability to calculate internal and external forces acting on those structures.

Unit 4: Modifying Existing Products and Understanding Control Systems. (Hack A Toy)

Students bring old electronic products and toys to class. They remove the main board and build an interface to a microcontroller and write software to re-invent the product. Previously, students have learned about the creative process and the use of tools in the design process. Through modifying existing toys and learning coding and electronics, students learn how to explore electronics, try out things, how to use electronics in the design process and change existing design based on modified electronics.

Introduction to Microcontrollers (The hardware consists of a simple open source hardware board.) Students demonstrate their knowledge of the programming language processing by debugging and writing source code.

Unit 5: Marketing and Statistics (Decolonize Xocolatl)

In order to build a product, there has to be a market. Students gain an understanding of markets, and how to market their products in the global marketplace. Additionally students learn about cost and mark-up.

Emerging Product Markets - Crowdsourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or suppliers. Students create a crowd-funding site website for their own product. They research other successfully funded products and design a product they believe can be funded.

Traditional Markets - Students learn about manufacturing cost, wholesale markup and retail markup.

Students learn to estimate PWM (Pulse Width Modulation)

Unit 6: Creatively Solving with Meaning and Purpose. (Fanny Pack)

Students learn more about the creative design process by experiencing a number of activities aimed at enhancing their ability to "think out of the box" both individually and in groups.

Students are given a design challenge to create both their best design and worst design, and then from the worst design ideas students have to develop them into a best design.

In addition to creativity, students learn about cost analysis, and how cost influences creativity and design. This unit is intended to change the creative thought process.

Students working in team to solve a design problem that focuses on using control systems as a technology strategy.

Unit 7: Culminating Project and Fluid Power (Origami)

Research Culminating Project, including research paper.

Presentation Skills- How to create an effective presentation to market your product

Intellectual Property Rights. Students produce an intellectual property statement for their final product and must answer the two key questions to obtain a patent; is the product novel and is it non-obvious to a skilled practitioner. Students write a report analyzing the two questions. Students complete a patent research of similar products to their final product, learning if their product is novel and if it is non-obvious to a skilled practitioner. Students determine if they have intellectual property that needs to be protected.

Students gain an understanding of fluid power, both hydraulic and pneumatic. They begin to recognize the power and control advantages of fluid power.

Unit 8: Prototype of Functional Concept and Kinematics (Skate)

The culminating project includes:

- Focus Group - Students present their design to a focus group
- Students modify their design based on feedback from focus group
- Design Circuit, software, CAD file
- Iterative Design - students build and test repeatedly until a design is optimized.
- Build product prototype utilizing all tools previously learned.
- Product Review with functional prototype
- Create Product Pitch to Industry Professionals
- Presentation Review with peer audience
- Working Prototype/Product Pitch Culminating Project to Industry Professional
- Students produce a sales and marketing document for their proposed final project. They must analyze the market, competition and product cost.