Intro to Engineering

Established 2008-2009

Revised 2014-2015

Revised 2016-2017

Revised 2018-2019

Revised 2020-2021

Revised 2021-2022

Revised 2022-2023

Revised 2023-2024

Revised 2024-2025

Mapping Science/Engineering Curriculum to NJSLS and related standards requirements

The curriculum for Intro to Engineering includes the 4 Engineering standards HS-ETS-1 through HS-ETS-4, cross referenced to Physical Science Standards HS-PS2, 1 and 6, HS-PS3, 1 to 5, HS-PS4 1 and 5, Earth Science standards Earth and Human Activity HS-ESS3, 1 to 5, for climate science and sustainability.

It also includes the NJ standards for Career Readiness, Life Literacies and Key Skills, NJSLS-CLKS, as well as the Amistad Law, N.J.S.A.18A 52:16A-88 and LGBTQ+ and Disabilities Law N.J.S.A.18A 35:4-35.

In November 2020, ASEE and AE3 released a white paper entitled "Towards a Framework for P-12 Engineering Learning" and later, "A Framework P-12 Engineering Learning, 2023, which outlines P-12 engineering education standards to unite the diverse NJSLS standards collection for engineering. The paper defines themes of Engineering Literacy, supported by Engineering Learning, with its own **Habits of the Mind**, **Engineering Knowledge**, and **Engineering Practices**. The following tables are taken from part 2 of the white paper. They point to the future direction of NJSLS science standards relationship with engineering.

Habits of the Mind

Optimism: Engineers, as a general rule, believe that things can always be improved. Just because it hasn't been done yet, doesn't mean it can't be done. Good ideas can come from anywhere and engineering is based on the premise that everyone is capable of designing something new or different
Persistence: Failure is expected, even embraced, as engineers work to optimize the solution to a particular challenge. Engineering – particularly engineering design – is an iterative process. It is not about trial and error. It is trying and learning and trying again.
Collaboration: Engineering successes are built through collaboration and communication. Teamwork is essential. The best engineers are willing to work with others. They are skilled at listening to stakeholders, thinking independently, and then sharing ideas.
Creativity: Being able to look at the world and identify new patterns or relationships or imagine new ways of doing things is something at which engineers excel. Finding new ways to apply knowledge and experience is essential in engineering design and is a key ingredient of innovation
Conscientiousness: Engineering has a significant ethical dimension. The technologies and methods that engineers develop can have a profound effect on people's lives. That kind of power demands a high level of responsibility to consider others and to consider the moral issues that may arise from the work
System Thinking: Our world is a system made up of many other systems. Things are connected in remarkably complex ways. To solve problems, or to truly improve conditions, engineers need to be able to recognize and consider how all those different systems are connected

Engineering Knowledge

Engineering Design	• Problem Framing • Information Gathering • Ideation	• Prototyping • Engineering Graphics • Decision Making	• Project Management • Design Methods • Design Communication
Material Processing	• Measurement & Precision • Manufacturing • Fabrication	• Material Classification • Joining • Casting/Molding/Forming	• Separating/Machining • Conditioning/Finishing • Safety
Quantitative Analysis	• Computational Thinking • Computational Tools	• Data Collection, Analysis, & Communication	• System Analytics • Modeling & Simulation
Professionalism	• Professional Ethics • Workplace Behavior/Operations • Honoring Intellectual Property	• Technological Impacts • Role of Society in Technological Development	• Engineering-Related Careers

Engineering Practice

Engineering Sciences	• Statics • Mechanics of Materials • Dynamics • Thermodynamics • Fluid Mechanics	• Mass Transfer & Separation • Chemical Reactions & Catalysis • Circuit Theory • Heat Transfer
Engineering Mathematics	• Engineering Algebra • Engineering Geometry & Trigonometry	• Engineering Statistics & Probability • Engineering Calculus
Engineering Technical Applications	• Electrical Power • Communication Technologies • Computer Architecture • Process Design • Structural Analysis • Environmental Considerations	• Hydrologic Systems • Transportation Infrastructure • Geotechnics • Chemical Applications • Mechanical Design • Electronics

Marking Period	**Unit Title**	**Recommended Instructional Days**
1	**Engineering Design and Systems Engineering**	**45**

NJSLS - Science: *TItle*	**NJSLS - Science: *Performance Expectations***	
Engineering Design	HS-ETS1-1 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 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 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 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.	**Recommended Activities, Investigations, Interdisciplinary Connections, and/or Student Experiences to Explore NJSLS-S within Unit**
FOUNDATION Disciplinary: *Core Idea*	**FOUNDATION Disciplinary: *Statement***	

• **ETS1-A Define and Delimit Problems** • **ETS1-B Develop solutions given constraints** • **ETS1-C Optimize solutions with constraints and tradeoffs**	• 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. (HS-ETS1-1) • 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) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) • 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	**Essential Question/s:** • How do engineers make use of basic science and measurement? • How do engineers document their work? • What is the engineering design method? • What is technology? • What is a constraint? • What is meant by optimization and trade-off? • How do engineers use brainstorming and methods of creative problem solving? • What is a prototype? • How do engineers use engineering design to plan a project? • What is an engineered system and its components? • What is a feedback loop and when is it open or closed? • What are the stages in an engineered system's lifecycle? • How do engineers use engineering design to analyze an existing system? • How do engineers use engineering design to reverse engineer an existing system to understand or repair it? **Activity Description**: For each topic, students start by reviewing notes, key terms in glossaries, problem sets, and other background information to prepare for each project or activity. **Topic 1 Math, Science, Measurement and Writing for Engineering** **Orientation and Tool Safety** Students tour locations of basic safety equipment and their use. Students review tool safety requirements, such as impact glasses and cutting boards, and sign safety contracts. [TECH,NJSLS-CLKS] **Physical science review and dimensional analysis** Problem sets done with the teacher, some with demos, to review basic physical science concepts. Practice with dimensional analysis, (units conversion) as engineering will use it. Students may begin to build their reference binders, virtual or paper. [HS-PS2, TECH, MA]

	(tradeoffs) may be needed. (HS-ETS1-2)	**Writing for Engineering** Students will examine samples of third person active voice writing, such as in cookbooks. They will then practice documentation by writing a step-by-step procedure for a simple task, such as opening a locker. Then describe a common device, a bicycle and how it works, to someone who has never seen one, such as Galileo or Newton. [ELA. TECH, SS, NJSLS-CLKS] **Topic 2 - Engineering Design** **Creative Problem solving and Engineering documentation** Students propose solutions to a list of five "brain teaser" problems. Some have a single solution and some have multiple solutions. After solving the problems as a class exercise students write a step-by-step solution for each in an engineering notebook. [HS-ETS1-2, ELA, MATH, TECH] **Brainstorming Activity** Teams of students brainstorm and research at least 3 of 6 engineering challenges which are poorly defined. Each one is missing vital information, such as cost and other constraints. Students must identify and then prioritize missing parameters for each scenario in preparation for proposing a solution. [HS-ETS1-2, ELA, TECH, SS,NJSLS-CLKS, spotlight on scientists] **Building and testing a prototype** Students will build and test a small elastic propeller driven device using a specific set of materials using only tape as a fastener. They may use the materials in any way. The device must slide across the floor in a straight line. Students will measure its speed and distance, and calculate how much kinetic energy is delivered by the elastics. They will present their prototypes and document the design process
FOUNDATION Science and Engineering Practices: *Core Idea*	**FOUNDATION Science and Engineering Practices: *Statement***	
• **Asking Questions and Defining Problems** Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.	• Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) • Design a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	

• **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions 9–12 builds on K– experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.		and testing in their engineering notebook. [HS-ETS1-2, MA, ELA, TECH, NJSLS-CLKS] **Topic 3: Engineering Project Management and Economics** **Park Design Project** Students prepare a design for a public park. They will be given dimensions and requirements from a local municipality for sidewalks, playgrounds, grass, trees, flowers etc. along with some options, such as a tennis or basketball court. Each item for the park comes with a cost, and installation time, for example, cement can be poured at a certain rate of square meters per day. Students will account for every square meter. Deliverables are: a layout design to scale on the 11 by 17 inch graph paper with a legend, a spreadsheet containing an itemized cost estimate, and a Gantt chart showing the installation schedule for all items in the park. The graph paper drawing may be substituted by a computer graphic with a scale. [HS-ETS1-1, HS-ETS1-4, MA, ELA, TECH, SS, ART, Climate change,NJSLS-CLKS] **Topic 4: Systems Engineering** **Systems Engineering - problem sets** Students examine small systems, such as a cell phone, toaster and bicycle, for input-process-output and controlling feedback loops. They propose designs for larger systems, such as plumbing or large appliances, and finish with defining the parts of a broad system, a commercial vegetable farm. [HS-ETS1-3, NJSLS-CLKS, Climate change, TECH, SS] **Systems engineering - Rube-Goldberg activity - short** Students will build and analyze each of the systems in the game of Mouse Trap for input, process, output, and any feedback. They will
FOUNDATION Crosscutting Concepts: ***Core Idea***	**FOUNDATION Crosscutting Concepts:** ***Statement***	
• Systems and System Models • Influence of Science, Engineering, and Technology on Society and the Natural World	• 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. (HS-ETS1-4) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1), (HS-ETS1-3)	

Social and Emotional Learning: ***Competencies***	**Social and Emotional Learning:** ***Sub-Competencies***	also determine any design issues with the function of the game. Students will document their work in their engineering notebooks. [HS-ETS1-3, ELA, TECH
● Self Management ● Responsible Decision Making ● Relationships Skills	● Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals ● Develop, implement, and model effective problem solving and critical thinking skills ● Identify the consequences associated with one's actions in order to make constructive choices ● Evaluate personal, ethical, safety, and civic impact of decisions ● Utilize positive communication and social skills to interact effectively with others ● Demonstrate the ability to prevent and resolve interpersonal conflicts in constructive ways ● Identify who, when, where, or how to seek help for oneself or others when needed	**Rube Goldberg Activity - long (optional depending on time)** Students view videos on Rube Goldberg machines. Students will work in teams to each construct a section of a Rube Goldberg device, and then connect their sections to run continuously, to accomplish a trivial task, for example, ring a bell on the teacher's desk or place an item in the sink. They must use a limited set of materials that can be found in the classroom without breaking anything or creating a safety problem. They will document their device based on energy transfers through each subsystem. [HS-ETS1-3, MA, ELA, TECH, ART] **Topic 5: Reverse Engineering and Engineering Analysis** Students will examine small "dollar store" devices such as LED bicycle lights, small flashlights, calculators, and stop watches, etc. to understand how each was constructed and intended to function. They will document the construction and function. Advanced students may reverse engineer a larger broken appliance to determine the cause of its problems. [HS-ETS1-3, ELA, TECH, NJSLS] **Interdisciplinary Connections: Content: NJSLS:** *Connections to NJSLS - English Language Arts* WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the

		author makes and to any gaps or inconsistencies in the account.(HS-PS2-1) RST.11-12-3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. (HS-ETS1-1),(HS-ETS1-3) RST.11-12-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific or technical context relevant to grades 11-12 texts and topics. (HS-ETS1-2, HS-ETS1-3) RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3) RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3) *Connections to NJSLS - Mathematics* MP.2 Reason abstractly and quantitatively. (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4) MP.4 Model with mathematics. (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3), (HS-ETS1-4) HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin

		in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)(HS-PS2-5) HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-2),(HS-PS2-4) HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4) HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2) HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2) HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.(HS-PS2-1) HSS-IS.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

Assessments (Formative) *To show evidence of meeting the standard/s, students will successfully engage within:*	Assessments (Summative) *To show evidence of meeting the standard/s, students will successfully complete:*
Formative Assessments: • Engineering notebooks - documentation of projects • Class discussions - and team brainstorming • Systems map for small and large systems • Group and individual hands on projects • Project Management cost estimate and Gantt chart	**Benchmarks:** • District Assessment **Summative Assessments:** • Engineering notebooks - documentation of projects • Physical science and dimensional analysis review • Topic vocabulary, project management and systems engineering exercises

Differentiated Student Access to Content:
Teaching and Learning *Resources/Materials*

Core Resources	Alternate Core Resources *IEP/504/At-Risk/ESL*	ELL Core Resources	Gifted & Talented Core Resources
• Engineering Binder notes and handouts, hardcopy or virtual • Engineering notebook, hardcopy or virtual	• TBN accommodations will be made based on student needs.	• TBN accommodations will be made based on student needs, students may use foreign language dictionaries or translator apps	• OnShape, 3D modeling and printing • Use of more tools. • Engineering team leaders

Supplemental Resources

Technology:
- Chromebooks and references in the Schoology class
- Engineering Design videos from various sources such as FIRST and Rube Goldberg videos for reverse engineering
- Google sheets, documents and slides

Other:
- Hands on project materials and tools, including Lego Mindstorm Evo kits and Arduino kits
- USPTO EquIP HQ website, resources and invention videos, freepatentsonline and Inventors Hall of Fame for intellectual property
- National Academy of Engineering website and 14 Grand Challenges website, engineering professional societies websites
- E-Week resources

Differentiated Student Access to Content: Recommended *Strategies & Techniques*			
Core Resources	**Alternate Core Resources *IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core**
• Start the year with a review of "classroom rules" to establish good conduct, team work, communications, and respect for all students. • Continuously show how Engineering Design Method is used for every project. • Do lessons and contracts on Tool Safety • Create work teams which make use of different abilities.	• Begin with a review of math, physical science and dimensional analysis to "level" diverse starting points of students who may be 9 to 12th graders at mixed skill levels. • Create work teams which make use of different skill levels. • Have students with higher skills demonstrate projects to encourage others. • Limit math to algebra	• Use bilingual dictionaries and digital translators. • Have students translate for each other. • Allow documentation in multimedia. Students with limited English may draw and label designs or present projects in other graphics.	• Students may propose variations and enhancements for projects

NJSLS CAREER READINESS, LIFE LITERACIES & KEY SKILLS	**Disciplinary Concept: *Career Awareness Planning (9.2 and 9.4)***	
	Core Ideas:	• Career planning requires purposeful planning based on research, self-knowledge, and informed choices. • There are ways to assess a business's feasibility and risk and to align it with an individual's financial goals
	Performance Expectation/s:	9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.

		9.2.12.CAP.8: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. 9.2.12.CAP.21: Explain low-cost and low-risk ways to start a business 9.4.12 .CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12 prof.CR3a). 9.4.12.CI.2: Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12 prof.CR2b, 2.2.12.LF.8). 9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1). 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a). 9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice). 9.4.12.DC.1: Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content (e.g., 6.1.12.CivicsPR.16.a). 9.4.12.DC.2: Compare and contrast international differences in copyright laws and ethics. 9.4.12.GCA.1: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3) 9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2). 9.4.12.IML.6: Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5). 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
	Career Readiness, Life Literacies, & Key Skills Practices	
	Disciplinary Concept: (9.4) ● Creativity and Innovation: CI	

	○ With a growth mindset, failure is an important part of success. ○ Innovative ideas or innovation can lead to career opportunities. ● Critical Thinking and Problem Solving: CT ○ Collaboration with individuals with diverse experiences can aid in the problem-solving process, particularly for global issues where diverse solutions are needed. ● Digital Citizenship: DC ○ Laws govern the use of intellectual property and there are legal consequences to utilizing or sharing another's original works without permission or appropriate credit. ○ Digital communities influence many aspects of society, especially the workforce. The increased connectivity between people in different cultures and different career fields have changed the nature, content, and responsibilities of many careers. ● Global and Cultural Awareness: GCA ○ Solutions to the problems faced by a global society require the contribution of individuals with different points of view and experiences. ● Information and Media Literacy: IML ○ Advanced search techniques can be used with digital and media resources to locate information and to check the credibility and the expertise of sources to answer questions, solve problems, and inform the decision-making. ○ In order for members of our society to participate productively, information needs to be shared accurately and ethically. ● Technology Literacy: TL ○ Digital tools differ in features, capacities, and styles. Knowledge of different digital tools is helpful in selecting the best tool for a given task.

New Jersey Legislative Statutes and Administrative Code (place an "X" before each law/statute if/when present within the curriculum map)									
	Amistad Law: *N.J.S.A. 18A 52:16A-88*		Holocaust Law: *N.J.S.A. 18A:35-28*		LGBT and Disabilities Law: *N.J.S.A. 18A:35-4.35*	x	Diversity & Inclusion: *N.J.S.A. 18A:35-4.36a*	x	Standards in Action: *Climate Change*

This material can be split up and mixed with Unit 3 during National Engineers Week and Black History Month, in February, and Women's History Month in March, during the time for Unit 3 - Engineering disciplines, so the 45 days do not have to run contiguously.

Marking Period	**Unit Title**	**Recommended Instructional Days**
2-3	**The World of Engineering**	**45**

NJSLS - Science: *TItle*	**NJSLS - Science: *Performance Expectations***	**Recommended Activities, Investigations, Interdisciplinary Connections, and/or Student Experiences to Explore NJSLS-S within Unit**
Engineering Design	HS-ETS1-1 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 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 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 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.	

<table>
<tr><th>FOUNDATION
Disciplinary:
Core Idea</th><th>FOUNDATION
Disciplinary:
Statement</th><th></th></tr>
<tr><td>ETS1-A Define and Delimit Problems
ETS1-B Develop solutions given constraints
ETS1-C Optimize solutions with constraints and tradeoffs</td><td>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. (HS-ETS1-1)
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)
Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)</td><td><u>Essential Question/s:</u>
What is intellectual property?
What are the types of intellectual property and how is each protected?
What is a patent?
What are the different types of patents?
What can be trademarked?
What is protected by copyright?
What is the difference between an invention and an innovation?
How do engineers use project management and engineering design thinking to plan a small business?
How does the engineering profession serve society?
What are engineering professional societies?
What are the National Academy of Engineering's "Great Achievements" and "Grand Challenges"?
How can Engineers meet the NAE's "Grand Challenges" ?
How have engineers and inventors of all backgrounds shaped the profession? (picture an engineer)
<u>Activity Description</u>:
For each topic, students start by reviewing notes, key terms glossaries, problem sets, and other background information to prepare for each project or activity.

Topic 6: Intellectual Property and Entrepreneurship

Intellectual property, Invention, and Innovation.
Students will explore the USPTO.gov website for "Extraordinary Inventors" videos, and Science of Innovation videos collection.</td></tr>
</table>

<table>
<tr><td></td><td>● 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. (HS-ETS1-2)</td><td rowspan="3">Students select two videos to explore in more depth, for questions such as “what is the patented property?”, “how is it used?” and “Is this idea an invention or an innovation?” [ELA, TECH, SS, ART, NJSLS-CLKS]

Evaluate a Patent
Students examine sample patents for what is required to patent a device, object, or process. They explore the "free patents online" website for a sample patent to critique. They must explain why the object was patented, find and identify the claims. They will be able to identify inventors and assignees, file and issue dates, patent life span, references to other patents, and explain how the drawings contribute to it. [MA, ELA, TECH, SS, NJSLS-CLKS]

Optional Patent Activity - Patent on a paper airplane
Patent US 4,377,052 a method for folding a paper airplane, is one of MANY patents on paper airplanes. Although it has a picture the description is obscure. Students should try to decipher, fold and fly it as a problem solving activity. Students will write a better description of how to fold it. [ELA, TECH, ART]

Small Business design and Elevator Speech competition
Students design a plan for a small business based on 5 criteria, an idea, a target customer base, a marketing scheme, a business environment evaluation (hours, location, competitors, suppliers etc.) and a list of start-up requirements (storefront, employees, investors, computers etc). Using their definitions of the business idea, marketing scheme and customer base, they then design an "elevator speech" to pitch their plan to a potential investor, and present it to the class. Students and the teacher score each speech on a 1 - 5 scale for each item. Students may use the USPTO’s “two patent challenge” exercise to generate a business start up idea. [ELA, TECH, SS, NJSLS-CLKS]</td></tr>
<tr><td>FOUNDATION
Science and Engineering Practices:
Core Idea</td><td>FOUNDATION
Science and Engineering Practices:
Statement</td></tr>
<tr><td>● Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
● Using Mathematics and Computational Thinking Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to</td><td>● Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)
● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)
● Design a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)
● Evaluate a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)</td></tr>
</table>

<table>
<tr>
<td>
analyze,represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions 9–12 builds on K– experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.
</td>
<td></td>
<td rowspan="3">
New toy/game design contest - optional
Student teams design a new DIY toy, game or device, made from a limited set of parts, popsicle sticks etc. with instructions set as if it were a new product. They then exchange their kit with another team that must build and evaluate it, using only their instruction set. [MA, ELA, TECH, ART, NJSLS-CLKS]

Engineering of toys (usually done the last days before winter break) Students examine several common toys, such as Jenga games, yoyos, tops etc, for their engineering principles. Documentation is available for yoyos and some others. Students can compare 3 types of yoyos, low friction, clutch and classic for differences that allow for different tricks. They will also observe what certain tops can flip over while spinning even when it appears to defy gravity. [MA, ELA, TECH, ART]

Topic 7: Engineering Societies and Outreach

Professional Societies and what they do
The teacher will tour the students through a series of professional society websites pointing out mission and vision statements, membership requirements and services they offer the engineering community and world at large. The teacher will then show the students the National Academy of Engineering, NAE, website's 14 Grand Challenges for the 21st Century. Students will then do a short report exploring a professional society of interest to them, such as ASME or SWE, for their mission statement, membership requirements, activities, and services, such as scholarships. They will also determine if this society has a college or high school chapter, and services for students. They will complete the report with a reflection on how their society can contribute to one of the 14 Grand Challenges. [ELA, TECH, SS, climate change, NJSLS-CLKS]
</td>
</tr>
<tr>
<td>FOUNDATION
Crosscutting Concepts:
Core Idea</td>
<td>FOUNDATION
Crosscutting Concepts:
Statement</td>
</tr>
<tr>
<td>Systems and System Models
Influence of Science, Engineering, and Technology on Society and the Natural World</td>
<td>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. (HS-ETS1-4)
New technologies can have deep impacts on society and the environment, including some that were not</td>
</tr>
</table>

<table>
<tr><td></td><td>anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1), (HS-ETS1-3)</td><td rowspan="3">Engineering Contributions to Society (This can be done during e-week, or for Black History and Women's History months and included LGBTQ+ contributions)
Students will explore the NAE's top 20 Engineering Achievements of the 20th century along with awards given by the NAE and National Inventors Hall of Fame. They will also explore profiles of famous engineers through videos such as "Dream Big". They will review a series of profiles of famous black inventors and engineers. They will complete the tour by checking out projects done by Engineers without Borders and Engineers for a Sustainable World. Students will prepare presentations, or reflections, either the contribution of a certain technology, or of a particular person. [ELA, TECH, SS, NJSLS-CLKS]

Interdisciplinary Connections: Content: NJSLS:

Connections to NJSLS - English Language Arts

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.(HS-PS2-1)

RST.11-12-3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. (HS-ETS1-1),(HS-ETS1-3)</td></tr>
<tr><td>Social and Emotional Learning:
Competencies</td><td>Social and Emotional Learning:
Sub-Competencies</td></tr>
<tr><td>● Self Management
● Responsible Decision Making
● Relationships Skills</td><td>● Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals
● Develop, implement, and model effective problem solving and critical thinking skills
● Identify the consequences associated with one's actions in order to make constructive choices
● Evaluate personal, ethical, safety, and civic impact of decisions
● Utilize positive communication and social skills to interact effectively with others
● Demonstrate the ability to prevent and resolve interpersonal conflicts in constructive ways
● Identify who, when, where, or how to seek help for oneself or others when needed</td></tr>
</table>

		RST.11-12-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific or technical context relevant to grades 11-12 texts and topics. (HS-ETS1-2, HS-ETS1-3) RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3) RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3) *Connections to NJSLS - Mathematics* MP.2 Reason abstractly and quantitatively. (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4) MP.4 Model with mathematics. (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3), (HS-ETS1-4) HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling (HS-PS2-1),(HS-PS2-2),(HS-PS2-4) (HS-PS2-5)

		HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-2),(HS-PS2-4) HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4) HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2) HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2) HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.(HS-PS2-1) HSS-IS.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

Assessments (Formative) ***To show evidence of meeting the standard/s, students will successfully engage within:***	**Assessments (Summative)** ***To show evidence of meeting the standard/s, students will successfully complete:***
<u>Formative Assessments:</u> ● Engineering notebooks - documentation of projects ● Group and individual hands on projects ● Elevator Speech “shark tank” competition with peer review	**<u>Benchmarks:</u>** ● District Assessment **<u>Summative Assessments:</u>** ● Engineering notebooks - documentation of projects ● Topic vocabulary, patent law and entrepreneurship.

• Discussions on invention and innovation, NAE Grand Challenges and contributions of engineering to society	• Reports and Presentations

Differentiated Student Access to Content: Teaching and Learning *Resources/Materials*			
Core Resources	**Alternate Core Resources *IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core Resources**
• Engineering Binder notes and handouts, hardcopy or virtual • Engineering notebook, hardcopy or virtual	• TBN accommodations will be made based on student needs.	• TBN accommodations will be made based on student needs, students may use foreign language dictionaries or translator apps	• OnShape, 3D modeling and printing

Supplemental Resources

Technology:
- Chromebooks and references in the Schoology class
- Google sheets, documents and slides

Other:
- Hands on project materials and tools, including Lego Mindstorm Evo kits and Arduino kits
- USPTO website, EquIP HQ resources and invention videos, freepatentsonline and Inventors Hall of Fame websites for intellectual property
- National Academy of Engineering website and 14 Grand Challenges website

Differentiated Student Access to Content: Recommended *Strategies & Techniques*			
Core Resources	**Alternate Core Resources *IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core**
• Start the year with a review of "classroom rules" to establish good conduct, team work, communications, and respect for all students.	• Begin with a review of math, physical science and dimensional analysis to "level" diverse starting points	• Use bilingual dictionaries and digital translators. • Have students translate for each other.	• Students may propose variations and enhancements for projects

• Continuously show how Engineering Design Method is used for every project. • Do lessons and contracts on Tool Safety • Create work teams which make use of different abilities.	of students who may be 9 to 12th graders at mixed skill levels. • Create work teams which make use of different skill levels. • Have students with higher skills demonstrate projects to encourage others. • Limit math to algebra	• Allow documentation in multimedia. Students with limited English may draw and label designs or present projects in other graphics.	

NJSLS CAREER READINESS, LIFE LITERACIES & KEY SKILLS	**Disciplinary Concept:** ***Career Awareness Planning (9.2 and 9.4)***	
	Core Ideas:	• Career planning requires purposeful planning based on research, self-knowledge, and informed choices. • There are ways to assess a business's feasibility and risk and to align it with an individual's financial goals
	Performance Expectation/s:	9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.2.12.CAP.8: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. 9.2.12.CAP.21: Explain low-cost and low-risk ways to start a business 9.4.12 .CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12 prof.CR3a). 9.4.12.CI.2: Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12 prof.CR2b, 2.2.12.LF.8). 9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1). 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem

		solving (e.g., 1.3E.12profCR3.a). 9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice). 9.4.12.DC.1: Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content (e.g., 6.1.12.CivicsPR.16.a). 9.4.12.DC.2: Compare and contrast international differences in copyright laws and ethics. 9.4.12.GCA.1: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3) 9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2). 9.4.12.IML.6: Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5). 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
	Career Readiness, Life Literacies, & Key Skills Practices	
	Disciplinary Concept: (9.4) ● Creativity and Innovation: CI ○ With a growth mindset, failure is an important part of success. ○ Innovative ideas or innovation can lead to career opportunities. ● Critical Thinking and Problem Solving: CT ○ Collaboration with individuals with diverse experiences can aid in the problem-solving process, particularly for global issues where diverse solutions are needed. ● Digital Citizenship: DC ○ Laws govern the use of intellectual property and there are legal consequences to utilizing or sharing another's original works without permission or appropriate credit. ○ Digital communities influence many aspects of society, especially the workforce. The increased connectivity between people in different cultures and different career fields have changed the nature, content, and responsibilities of many careers.	

	• Global and Cultural Awareness: GCA
	  ○ Solutions to the problems faced by a global society require the contribution of individuals with different points of view and experiences.
	• Information and Media Literacy: IML
	  ○ Advanced search techniques can be used with digital and media resources to locate information and to check the credibility and the expertise of sources to answer questions, solve problems, and inform the decision-making.
	  ○ In order for members of our society to participate productively, information needs to be shared accurately and ethically.
	• Technology Literacy: TL
	  ○ Digital tools differ in features, capacities, and styles. Knowledge of different digital tools is helpful in selecting the best tool for a given task.

New Jersey Legislative Statutes and Administrative Code (place an “X” before each law/statute if/when present within the curriculum map)									
x	Amistad Law: *N.J.S.A. 18A 52:16A-88*		Holocaust Law: *N.J.S.A. 18A:35-28*	x	LGBT and Disabilities Law: *N.J.S.A. 18A:35-4.35*	x	Diversity & Inclusion: *N.J.S.A. 18A:35-4.36a*	x	Standards in Action: *Climate Change*

Marking Period	**Unit Title**	**Recommended Instructional Days**
2-4	**Engineering Disciplines and Final Project**	**90**

NJSLS - Science: *TItle*	**NJSLS - Science: *Performance Expectations***	**Recommended Activities, Investigations, Interdisciplinary Connections, and/or Student Experiences to Explore NJSLS-S within Unit**
Engineering Design	HS-ETS1-1 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 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 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 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.	
FOUNDATION Disciplinary: *Core Idea*	**FOUNDATION Disciplinary: *Statement***	

• **ETS1-A Define and Delimit Problems** • **ETS1-B Develop solutions given constraints** • **ETS1-C Optimize solutions with constraints and tradeoffs**	• 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. (HS-ETS1-1) • 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) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) • 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	**Essential Question/s:** • What are Engineering Disciplines and how do engineers apply their craft? • What is mechanical work, and how does mechanical advantage change the delivery of work? • What are simple machines and mechanisms? • What is mechanical efficiency? • What is a gear ratio and how is it related to mechanical advantage? • What are the elements of structure and how do engineers use them? • How do engineers make use of the laws of conservation of mass and energy? • How do engineers measure heat energy? • How do engineers make use of Ohm's law to measure current, voltage and resistance? • How do engineers make use of parallel and series circuits? • What is the difference between AC and DC current and how do engineers make use of each? • How do engineers use the energy of sound waves? • How do engineers make use of resonators and radiators in musical instrument design? • How do engineers evaluate a process with a multidisciplinary approach? • What are possible career paths for different engineering disciplines? **Activity Description**: For each topic, students start by reviewing notes, key terms glossaries, problem sets, and other background information to prepare for each project or activity. **Topic 9 - Structural and Mechanical Engineering**

	(tradeoffs) may be needed. (HS-ETS1-2)	**Bridge Stories** Students explore the history of bridge building through the stories of famous bridges, e.g. starting with local bridges, the Brooklyn, Verrazano, Bayonne bridge, and how "Galloping Gertie" the Tacoma Narrows bridge disaster contributed to the development of better bridges. They will also identify the elements which constitute different types of bridges, trusses, cables, and arches etc. [ELA, TECH, SS, ART, 21st Century] **Truss Bridge build (if time permits)** Construction challenge: Using only 35 standard popsicle sticks and 1-2 glue sticks, construct a truss bridge to span an 8 inch gap between 2 desks and support a minimum of 12lbs hung or supported on its center. Students will identify the type of truss and document design plans in the engineering notebooks. [MA, TECH, ART] **Catenary Arch build** Students build a catenary arch by tracing the shape of a hanging chain, a catenary, then constructing a pattern of 9 or 11 pieces to trace on cardboard. They add a center support and feet to each section to make it stand. Students who can finish the arch and be photographed beside a free standing arch in the time allowed get 100. Five points will be deducted for every finger supporting the arch if it does not free stand in the time allowed. [MA, TECH, ART] **Building the Great Cathedrals (PBS video and website)** **(This may be done as a part of a "survey" of architecture)** Students watch "Building the Great Cathedrals" video, or the video background on the website, and examine the changes in building technology, the pointed arch, ribbed vault and flying buttress, as the first example of "curtain wall" building that paved the way for modern skyscrapers. [ELA, TECH, SS, ART, NJSLS-CLKS]
FOUNDATION Science and Engineering Practices: *Core Idea*	**FOUNDATION Science and Engineering Practices: *Statement***	
• **Asking Questions and Defining Problems** Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze,represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.	• Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) • Design a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	

<table>
<tr>
<td>

- **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions 9–12 builds on K– experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.

</td>
<td></td>
<td rowspan="3">

Gear box project
Students explore gear ratios using LEGO gears. They must build and test four different compound gear combinations to compare the behavior and mechanical advantage of a gear train with a gear ratio greater than 1, (geared for torque) and a gear ratio less than 1, (geared for speed). They will build up a small car around their gearboxes and race them to compare 2 speed modes and 2 torque modes, and then document results in their engineering notebooks. [MA, TECH, ELA, NJSLS-CLKS]

Hydraulic arm build - optional, time permitting
Using "Teacher Geek" kits for hydraulic arms students will build an arm that can lift a small object and place it on a target, and move in 3 directions, up and down, sideways, and back and forth. Students will also explore the difference between hydraulic and pneumatic devices, and evaluate the mechanical advantage of the pistons in their device and others like it. [MA, TECH, NJSLS-CLKS]

Topic 10: Chemical Engineering

Designing a Manufacturing Process
This project combines mechanics with food processing for chemical engineering Students will research candy coating processes, such as the making of M&Ms. Using one pint plastic jars as a prototype mixing container, they will design a mixer and process, and calculate a rate for powder coating for their device. They will propose a scale up model. They will demonstrate their prototype and document designs in their engineering notebooks. [MA, ELA, TECH, NJSLS-CLKS]

Chocolate manufacture - optional
Students explore Food Science labels. Using the per gram nutritional information on the labels of raw chocolate, coconut oil, and honey (or

</td>
</tr>
<tr>
<td>

FOUNDATION
Crosscutting Concepts:
Core Idea

</td>
<td>

FOUNDATION
Crosscutting Concepts:
Statement

</td>
</tr>
<tr>
<td>

- Systems and System Models
- Influence of Science, Engineering, and Technology on Society and the Natural World

</td>
<td>

- 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. (HS-ETS1-4)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1), (HS-ETS1-3)

</td>
</tr>
</table>

Social and Emotional Learning: *Competencies*	**Social and Emotional Learning:** *Sub-Competencies*	other sweeteners) students follow a recipe for chocolate fudge sauce, and for a given sample, e.g. 10 grams, calculate the nutritional label information. They can also combine their 10 gram chocolate sauce with another sample of known nutrition value, a cookie, or a sample of dried fruit or nuts, for a new product and calculate its nutritional label. Students will also watch demo videos for a story of how chocolate is grown, harvested, and prepared into candy and other products. [MA, TECH, ELA, SS, ART,NJSLS-CLKS] **Topic 11: Environmental Engineering (new)** **Research exercise - "rethink the plastic over-packaging of food"** Students view the "rethink the shopping cart" video, research environmental issues of the food packaging. Using brainstorming they will map out the requirements for sustainable food packaging. propose a "future" for plastic containers and other non-sustainable packaging, with recommendations for new sustainable materials or better recycling, or some combination. [ELA, TECH, SS, Climate Change, NJSLS-CLKS] **Topic 12: Electrical Engineering** **Ohm's law project** Students start by measuring current and voltage drop through small light bulbs and resistors in series. They then construct a series circuit around the light bulb and the battery, and measure the voltage drop across the light bulb, and current flow in the circuit as they reduce the voltage from 4 batteries to 1. They repeat this with the 100Ω and 47Ω resistors, in the place of the lightbulb. Students then graph the data, x=mA and y=volts, to show that the slope of the lines for the two resistors are equal to their rated resistances, proving the identity of Ohm's law, V= I x R, as a direct example of y = mx + b. The line for the light bulb will be for a variable resistor, a parabola, and students
• Self Management • Responsible Decision Making • Relationships Skills	• Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals • Develop, implement, and model effective problem solving and critical thinking skills • Identify the consequences associated with one's actions in order to make constructive choices • Evaluate personal, ethical, safety, and civic impact of decisions • Utilize positive communication and social skills to interact effectively with others • Demonstrate the ability to prevent and resolve interpersonal conflicts in constructive ways • Identify who, when, where, or how to seek help for oneself or others when needed	

		will be able to show Ohm's law in a non-linear relationship $V= m \times I^2$. [MA, TECH, ELA] **Story of Nikola Tesla (PBS video and/or website)** Students watch the video of the story of Nikola Tesla and answer key questions to learn of his contribution to the development of AC current, motors, radio and other modern technology, [ELA, TECH, SS, NJSLS-CLKS] **Story of Radio** Students explore the history of radio and the range of applications and devices which use the radio band of the electromagnetic spectrum, along with the stories of major contributors to this technology. [ELA, TECH, SS, NJSLS-CLKS] **Motor build project - optional - time permitting** *New kits for this project may not be available, however, students may assemble the motors from parts from previous years.* Students will examine the workings of the "world's simplest motor", a coil of wire, a magnet, a holder and a D-Battery. Students will then wind their own motors from a kit where finished motors can be mounted to small boats and raced. Students will balance their motor boat in water and race them for a specific distance in the racing trough. They will calculate kinetic energy based on speed and mass and estimate efficiency based on the voltage of the battery and the voltage drop of the motor under load. They will record results in their engineering notebooks. [MA, TECH, ELA] **Solar/Hydrogen cell/Battery cars -** *optional, can be done in part* Students build the Thames and Kosmos model cars and race them on a 1-2m track in battery, solar cell and hydrogen cell modes. They measure the voltage available and voltage under load for each mode and estimate the efficiency. They then calculate the speed and kinetic

		energy to show how the efficiency translates to motion. They record results in their engineering notebooks. [MA, TECH, ELA] **Sound and Music Demos** As preparation for the Instrument Design project students view videos and test demos of various small musical instruments, such as thumb pianos, tuning forks, recorders, glass harps, theramins and small stringed instruments. [MA, TECH, ELA] **Musical Instrument Design** Using the equations for musical instrument design and construction from the problem sets, students will either design and build a working musical instrument, or prepare a report/presentation on the history, design and function of an existing musical instrument. Students building an instrument may select a conventional or made up design and can use a kit. They must submit a design and requests for parts in their notebooks before starting, otherwise they must supply their own materials. They must give a short demo of the finished product and write a short user guide with play and care instructions as if they were to market it as a new product. Students reviewing an existing instrument may use google slides or a google doc. They must include a short history, construction details, typical materials used, how the instrument is played and how it resonates and radiates sound. [MA, TECH, ELA, ART, SS,NJSLS-CLKS] **Part 4 - Final Project - counts as last test grade and DA4** Students watch any episode of How It's Made and evaluate the process for five aspects, 1, Engineering and systems, with the feedback loops and controls identified, 2, Intellectual Property, showing patented items, trade secrets, and other IP, 3 Economics, identifying the most expensive inputs, outputs or machines, and how they manufacturer makes money. 4, Ethical and contractual elements, includes sustainability, worker safety, environmental concerns such as

		pollution and recycling, 5 An entrepreneur's take, what would they make of this process if they owned the company. Students will compile their findings in a short paper, (final test grade) and in a Google slides presentation for the class, not less than 5 minutes and not more than 10 minutes. (DA4) Students will rate each other's presentations on the 5 aspects on a 1 to 5 scale. [MA, TECH, ELA, SS, ART, NJSLS-CLKS] **Interdisciplinary Connections: Content: NJSLS:** *Connections to NJSLS - English Language Arts* WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.(HS-PS2-1) RST.11-12-3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. (HS-ETS1-1),(HS-ETS1-3) RST.11-12-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific or technical context relevant to grades 11-12 texts and topics. (HS-ETS1-2, HS-ETS1-3) RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video,

		multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3) RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3) *Connections to NJSLS - Mathematics* MP.2 Reason abstractly and quantitatively. (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4) MP.4 Model with mathematics. (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3), (HS-ETS1-4) HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling (HS-PS2-1),(HS-PS2-2),(HS-PS2-4) (HS-PS2-5) HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-2),(HS-PS2-4)

		HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4) HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2) HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2) HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.(HS-PS2-1) HSS-IS.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

Assessments (Formative) ***To show evidence of meeting the standard/s, students will successfully engage within:***	**Assessments (Summative)** ***To show evidence of meeting the standard/s, students will successfully complete:***
Formative Assessments: ● Engineering notebooks - documentation of projects ● Class discussions on short topics ● Group and individual hands on projects	**Benchmarks:** ● District Assessments - problem set DA3, presentation, DA4 **Summative Assessments:** ● Engineering notebooks - documentation of projects ● Topic vocabulary, engineering disciplines ● Reports. presentations, problem sets

Differentiated Student Access to Content:
Teaching and Learning *Resources/Materials*

Core Resources	Alternate Core Resources *IEP/504/At-Risk/ESL*	ELL Core Resources	Gifted & Talented Core Resources
• Engineering Binder notes and handouts, hardcopy or virtual • Engineering notebook, hardcopy or virtual	• TBN accommodations will be made based on student needs.	• TBN accommodations will be made based on student needs, students may use foreign language dictionaries or translator apps	• OnShape, 3D modeling and printing

Supplemental Resources

Technology:

- Chromebooks and references in the Schoology class
- Engineering Design videos and How it's Made videos
- Google sheets, documents and slides

Other:

- Hands on project materials and tools, including Lego Mindstorm Evo kits and Arduino kits
- USPTO website, EquIP HQ resources and invention videos, freepatentsonline and Inventors Hall of Fame websites for intellectual property
- National Academy of Engineering website and 14 Grand Challenges website

Differentiated Student Access to Content: Recommended *Strategies & Techniques*

Core Resources	Alternate Core Resources *IEP/504/At-Risk/ESL*	ELL Core Resources	Gifted & Talented Core
• Start the year with a review of "classroom rules" to establish good conduct, team work, communications, and respect for all students. • Continuously show how Engineering Design Method is used for every project.	• Begin with a review of math, physical science and dimensional analysis to "level" diverse starting points of students who may be 9 to 12th graders at mixed skill levels.	• Use bilingual dictionaries and digital translators. • Have students translate for each other. • Allow documentation in multimedia. Students with limited English may draw and label designs or	• Students may propose variations and enhancements for projects

• Do lessons and contracts on Tool Safety • Create work teams which make use of different abilities.	• Create work teams which make use of different skill levels. • Have students with higher skills demonstrate projects to encourage others. • Limit math to algebra	present projects in other graphics.	

NJSLS CAREER READINESS, LIFE LITERACIES & KEY SKILLS	**Disciplinary Concept:** ***Career Awareness Planning (9.2 and 9.4)***	
	Core Ideas:	• Career planning requires purposeful planning based on research, self-knowledge, and informed choices. • There are ways to assess a business's feasibility and risk and to align it with an individual's financial goals
	Performance Expectation/s:	9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.2.12.CAP.8: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. 9.2.12.CAP.21: Explain low-cost and low-risk ways to start a business 9.4.12 .CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). 9.4.12.CI.2: Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8). 9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1). 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a). 9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental

		justice). 9.4.12.DC.1: Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content (e.g., 6.1.12.CivicsPR.16.a). 9.4.12.DC.2: Compare and contrast international differences in copyright laws and ethics. 9.4.12.GCA.1: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3) 9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2). 9.4.12.IML.6: Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5). 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
	Career Readiness, Life Literacies, & Key Skills Practices	
	Disciplinary Concept: (9.4) ● Creativity and Innovation: CI ○ With a growth mindset, failure is an important part of success. ○ Innovative ideas or innovation can lead to career opportunities. ● Critical Thinking and Problem Solving: CT ○ Collaboration with individuals with diverse experiences can aid in the problem-solving process, particularly for global issues where diverse solutions are needed. ● Digital Citizenship: DC ○ Laws govern the use of intellectual property and there are legal consequences to utilizing or sharing another's original works without permission or appropriate credit. ○ Digital communities influence many aspects of society, especially the workforce. The increased connectivity between people in different cultures and different career fields have changed the nature, content, and responsibilities of many careers. ● Global and Cultural Awareness: GCA ○ Solutions to the problems faced by a global society require the contribution of individuals with different points of view and experiences.	

	• Information and Media Literacy: IML
	  ◦ Advanced search techniques can be used with digital and media resources to locate information and to check the credibility and the expertise of sources to answer questions, solve problems, and inform the decision-making.
	  ◦ In order for members of our society to participate productively, information needs to be shared accurately and ethically.
	• Technology Literacy: TL
	  ◦ Digital tools differ in features, capacities, and styles. Knowledge of different digital tools is helpful in selecting the best tool for a given task.

New Jersey Legislative Statutes and Administrative Code (place an "X" before each law/statute if/when present within the curriculum map)									
	Amistad Law: *N.J.S.A. 18A 52:16A-88*		Holocaust Law: *N.J.S.A. 18A:35-28*		LGBT and Disabilities Law: *N.J.S.A. 18A:35-4.35*	x	Diversity & Inclusion: *N.J.S.A. 18A:35-4.36a*	x	Standards in Action: *Climate Change*

.