Engineering

Established 2009-2010
Revised 2014-2015
Revised 2018-2019
Revised 2020-2021
Revised 2021-2022
Revised 2022-2023

Course Description:

- Second year **Engineering** or “Senior” Engineering is a portfolio class where students who have successfully completed Intro to Engineering with a mastery of Engineering Design and good project management skills may select a portfolio of long term and competitive engineering projects.
- Students are expected to draw on experiences from Intro to Engineering.
- The teacher serves as mentor and facilitator.
- The projects may be solo or with a team.
- Students are encouraged to have multiple projects as time permits and can work on them in parallel or series
- Grading is based on how well students meet their own goals.
    - Students will set goals on a timeline, usually weekly, to monitor progress.
- Students will complete the year with a legacy project that contributes to future engineering classes.
- Project milestones and deadlines are set by exterior criteria, e.g. project submission dates, robotics competition schedule, not a school timetable. The same project may span different marking periods from year to year.
- Students will be asked to include sustainability, efficiency use of materials, and economics in all engineering plans

Projects that come with the class are:

- FIRST Tech Challenge robotics team 3774, with mentorship and collaborations with teams 4890 and 16557
- Technology Student Association Chapter leadership and state conference projects, it can include organizing the teams for TEAMS.
- Science fair competitions and Science Talent Search for eligible students
- Other ad hoc student selected competitions, such as Samsung Solve for Tomorrow and SteamTank
- 3D modeling for CAD applications and 3D printing

Expectations and Pacing Guide - subject to external schedules and deadlines

MP1 requirements - Students must have project plans and rough schedules for the year in place by the end

- Students on the robotics teams must have
  - a completed team roster
  - a competition schedule set with the FTC NJ
  - a first pass build to meet the year's challenge - basic chassis with plans for more features
  - a documentation format and portfolio framework
  - sketches and 3D models of their first draft along with the thought process
  - a plan to meet awards criteria
- Students doing TSA projects must have
  - a meeting plan and chapter officers named
  - a preliminary plan for the winter and spring, if possible for TEAMS, and the state conference
  - a work plan, if a long term project has been selected
- Students doing science fair must have
  - competition applications approved
  - a preliminary research plan
  - experiments or prototypes planned/started

MP2 requirements - Students have committed to and/or participated in competitive events

- Students doing science fair have completed entries and are prepared to compete
- Students in robotics teams have completed early competitions and have a plan for getting into the state tournament
- Students doing TSA have prepared for the state conference and organized younger students for it and possibly TEAMS.

MP3 requirements - Students follow through on competitive events

- Students doing the NJ TSA State Conference have prepared for their events and organized younger students.
- Students doing robotics prepare for the league and possible state tournaments.

MP4 requirements - Students complete competitive events and document the year for a legacy project, or prepare a new project for legacy

Mapping Science/Engineering Curriculum to NJSLS and related standards requirements

The curriculum for Engineering includes the 4 Engineering standards HS-ETS-1 through HS-ETS-4.
It also includes the NJ standards for Career Readiness, Life Literacies and Key Skills, NJSLS-CKLS, 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.

When doing competitive engineering projects for programs such as FIRST Tech Challenge, Technology Student Association and Science Fair students are required to take a holistic approach. The most competitive projects must involve values of diversity, inclusion, teamwork, and community involvement as well as the science and the technology. In this way students meet the wider state standards.

Marking Period	Unit Title	Recommended Instructional Days
1-4	**Major Project Planning, Execution and Documentation**	**180**

NJSLS - Science: ***TItle***	**NJSLS - Science:** ***Performance Expectations***	**Recommended Activities, Investigations, Interdisciplinary Connections, and/or Student Experiences to Explore NJSLS-S within Unit**
Project portfolio building and project goals	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	**Essential Question/s:** ● How do I/we use the Engineering Design Method to define, manage and achieve the goals of my/our projects? ● What tech or other skills do I/we need to meet our project goals and how do I/we get them? **Activity Description**: **Orientation and Project Selection** **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] **Skills Assessment and Project Selection** Students set early goals for new skills and project choices for the year. The teacher will review plans with each student or team to create a work plan. Weekly goals will be set by the work plan for milestones and accomplishments. [Tech, ELA, NJSLS-CLKS] **3D modeling** All students will learn basic 3D modeling skills using OnShape for the purpose of using the 3D printer.. Students may also use Fusion360 or

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<td>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 (tradeoffs) may be needed. (HS-ETS1-2)</td>
<td rowspan="3">other autocad programs. The robotics team will take more time and learn modeling with the FTC Kit of Parts. [Tech, NJSLS-CLKS]

FIRST Tech Challenge robotics team - 3774
Requirements
- All students must register for 3774 with parental approval on the FIRST team website and be able to compete on the weekend team schedule.
- All students must review all the required skills, robot design, 3D modeling, coding, wiring, documentation, and team organization, before diversifying to a specific skill.
- All students must contribute work summaries according to weekly goals to the engineering notebook.
- All students must agree to the team conduct code and practice Gracious Professionalism, keeping in mind diversity and inclusion.
- All team members must agree to work with and mentor, (or be mentored by) the school’s sister teams 4890 and 16557.
- Project schedule, set by the league and national organization, starts with the game reveal in early September, and continues to the league tournaments in mid-February, or to the state tournament, Garden State Rumble, in mid March, or to the World Tournament in late April if teams advance.
- All team members will set weekly goals based on build, testing, coding, documentation, and team building needs.
- Before and after each major event or milestone team members will hold a SWOT, “strengths”, “weaknesses”, “opportunities” and “threats” evaluation of their performance, and document the session for their notebook.
- All team members will participate in “team outreach” in some way. This can include preparing robotics demos for 8th grade orientation, back to school night, engineering girls night, or other open house or</td>
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<td>FOUNDATION
Science and Engineering Practices:
Core Idea</td>
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Science and Engineering Practices:
Statement</td>
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<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</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 trade off 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 trade off considerations. (HS-ETS1-3)</td>
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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. ● **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.		community events. They can also prepare a joint event with another department or club in the school. [ELA. TECH, SS, NJSLS-CLKS] **Technology Students Association and TEAMS**. Students will assume the roles of the TSA chapter officers and create a meeting schedule for officers and members at large. Members at large can include other class members, and the rest of the student population. They will open general club activities and competitions to the school at large. - For the state competition they will pick projects and set a schedule for goals. They will also invite other students to select projects and work with the teacher to mentor all projects. - For TEAMS, if this is done, they will work with Intro to Engineering to get as many students as possible to participate to fill the TEAMS, in particular the 9-10th grade level teams. They will coordinate scenario selections, team essays and kits for the build section of the test. [ELA, TECH, SS, Climate Change, NJSLS-CLKS] **Science Fair and other Science or tech Competitions** - Students must decide as soon as possible in order to ensure entry in the various competitions as some slots are limited. The teacher will coordinate entries with the research class, science department or other outside organization. - To enter the competition the student, or team, must review the competition requirements with the teacher, so the teacher may properly sponsor or advocate for their entry. - The student or team then sets their schedule and goals for the project with the teacher, along with check-ins to stay on target, to meet all the requirements of the project. [ELA, TECH, SS, Climate Change, NJSLS-CLKS] **Legacy Project - done after all competitive projects** This project is the student's final gift to the school for the engineering
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	

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<tr><td></td><td>costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1), (HS-ETS1-3)</td><td rowspan="3">program. It can be anything from improved documentation procedures for projects, to a new organization for the engineering lab, to a gadget built for teaching engineering, to a new club. Students should review their ideas with the teacher first. Students will present it as part of their final district assessment [ELA, TECH, SS, Climate Change, NJSLS-CLKS]

Interdisciplinary Connections: Content: by 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)</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>
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		RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (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.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (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 ● Weekly progress check-ins ● SWOT for FIRST and post project reviews for others ● Group and individual hands on projects	**Benchmarks:** ● District Assessment 1 - project status and systems review ● District Assessment 2 - project statues and basic skills ● District Assessment 3 - General Engineering Knowledge Review ● District Assessment 4 - Project presentations and legacy projects

	Summative Assessments: ● Engineering notebooks - documentation of projects ● Competitions and results

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 ● Engineering notebook	● 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 and 3D modeling and printing

Supplemental Resources

Technology:
- Chromebooks
- Schoology
- OnShape
- Engineering Design and coding videos from various sources such as FIRST (for virtual learning)
- Google sheets, documents and slides

Other:
- Technology Student Association Resources
- Society of Science and the Public Resources
- National Academy of Engineering 14 Grand Challenges
- Hands on project materials and tools
- Robotics kits, also VEX, Lego Mindstorm Evo kits and Arduino kits

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

Core Resources	Alternate Core Resources *IEP/504/At-Risk/ESL*	ELL Core Resources	Gifted & Talented Core

• Virtual and physical versions of my “classroom rules” to establish good conduct, team work, communications, and respect for all students. • Continuously show how engineering design method can be used in every project. • Do lessons and contracts on Tool Safety, and stress safety throughout the year.	• Create work teams which make use of different skills. • Allow students to document in all media	• 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.
	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 9.4.12 .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., 1.4.12prof.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.7: Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a). 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.2: Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources. 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 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*	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*