FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

OFFICE OF CURRICULUM AND INSTRUCTION

SCIENCE AND ENGINEERING

HONORS ENGINEERING RESEARCH

Grade Level: 12

Credits: 5

BOARD OF EDUCATION ADOPTION DATE:

AUGUST 31, 2015

FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

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HONORS ENGINEERING RESEARCH

COURSE PHILOSOPHY

Honors Engineering Research focuses on the scientific practices that are necessary to be successful in both research and industrial settings. This course goes beyond content knowledge and application and emphasizes the synthesis of imagining, planning, developing, documenting, building, and completing projects.

COURSE DESCRIPTION

In *Honors Engineering Research*, students can concentrate on a research project or an individual Supervised Learning Experience (SLE). The goal of the research project is for students to independently investigate a science and/or engineering problem or scenario of their choosing and develop a project based on this problem or scenario. The goal of the SLE is for students to work collaboratively with an engineering team in an authentic setting.

To reach these goals, students will complete either two semester long research projects, or one semester long research project and one SLE. Students focus on a topic from the following areas of study: astronomy, computer interfacing, fluid statics and dynamics, laser art and communication, mathematical modeling, magnetic forces and fields, robotics, and alternate energy sources and their environmental costs. At the end of their project or SLE, students will present their project or experience to peers, teachers, and administrators.

COURSE SUMMARY

COURSE GOALS

CG1: Students will design and conduct an independent research project or participate in a supervised learning experience in science and/or engineering.
CG2: Students will effectively communicate and justify their research project or service learning experience to an audience using appropriate techniques and tools.

COURSE ENDURING UNDERSTANDINGS	COURSE ESSENTIAL QUESTIONS
CEU1: Research, project design, and project development are the primary tasks of engineers.	CEQ1: What is the best way to tackle a large project?
CEU2: Oral and visual presentation skills are essential tools for engineers.	CEQ2: How do I best tailor my communications based on my audience and project?
CEU3: Detailed records of research, project development, and design implementation are essential to successful engineers.	CEQ3a: What makes documentation reliable and effective? CEQ3b: Is there a best way to document a project or experience?

GOALS & PACING

TITLE	GOALS	RECOMMENDED DURATION
Supervised Learning Experience	LG1: Students will work collaboratively in a laboratory setting with a team of scientists and/or engineers on an authentic project. CG2: Students will effectively communicate and justify their research project or service learning experience to an audience using appropriate techniques and tools.	1 semester
Research Project	LG1: Students will design and conduct an independent research project in science and/or engineering. CG2: Students will effectively communicate and justify their research project or service learning experience to an audience using appropriate techniques and tools.	1 semester

HONORS ENGINEERING RESEARCH
SUPERVISED LEARNING EXPERIENCE **SUGGESTED DURATION: 1 semester**

SUPERVISED LEARNING EXPERIENCE OVERVIEW	
LEARNING GOALS	
LG1: Students will work collaboratively in a laboratory setting with a team of scientists and/or engineers on an authentic project. CG2: Students will effectively communicate and justify their research project or service learning experience to an audience using appropriate techniques and tools.	
LEARNING SCALE: LG1	
4	In addition to the score 3 performance, the student's contributions to the team assisted in the team reaching its goal.
3	The student can: • work cooperatively with an engineering team on appropriate activities; • contribute to group projects; • receive positive evaluations from team members and school personnel.
2	The student works well with an engineering team with mostly positive evaluations by team members and school personnel.
1	The student has some difficulty performing tasks or working with the engineering team, and does not receive positive evaluations.
0	A lack of effort and industry caused the student to have unfavorable interactions and comments from the engineering team and school personnel.
LEARNING SCALE: CG2	
4	In addition to the score 3 performance, the student can showcase their supervised learning experience in district wide presentations.
3	The student can: • clearly state the team goals, and describe the role of each team member in setting and meeting these goals; • present relevant information in a logical manner; • demonstrate that appropriate outside and background research has been done; • produce and use appropriate diagrams and graphs to clearly support and explain the team's and the student's work; • produce a presentation appropriate for a given target audience and time frame; • demonstrate appropriate use of language to clearly communicate their progress and understanding; • document their role and the roles of other team members in achieving the team goal(s).
2	The student has made progress toward all score 3 performances and has demonstrated proficiency with the majority of them.
1	The student, with assistance, has made progress toward a majority of the score 3 performances.
0	Even with help, the student has not made significant progress toward the majority of the level 3 performances.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Engineers and scientists generally work in teams and often have to create partnerships outside of the team.	EQ1a: How do people not part of team still have impact on the work of the team? EQ1b: How does your work outside the team influence the team goal?
EU2: All members of an engineering or scientific working group can play a valuable part in the engineering and scientific processes.	EQ2: How can I, as a student, help a team achieve its goal?
EU3: In order to meet their goals, engineering and scientific teams should be comprised of members with various backgrounds, knowledge, and skills.	EQ3a: How can teams take advantage of individual strengths? EQ3b: How can members of a team adapt to work together?

NGSS & COMMON CORE STANDARDS
NGSS: 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. **CCSS:** 11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. 11-12.WHST.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. 11-12.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.

ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1, CG2 EU1, EQ1a, b EU2, EQ2 EU3, EQ3a, b HS-ETS1- 1, 2, 3, 4 11-12.WHST.2, 4, 9 DOK 3	At the end of the Supervised Learning Experience (SLE), students will present their experience to the class. Students will also be assessed on their activities log book and their supervisory evaluations.

POSSIBLE SLE PLACEMENTS
Engineering firms Manufacturing firms Software development firms Telecommunications firms Solar energy installation companies Public utility companies

HONORS ENGINEERING RESEARCH
RESEARCH PROJECT **SUGGESTED DURATION: 1 semester**

RESEARCH PROJECT OVERVIEW	
LEARNING GOALS	
LG1: Students will design and conduct an independent research project in science and/or engineering. CG2: Students will effectively communicate and justify their research project or service learning experience to an audience using appropriate techniques and tools.	
LEARNING SCALE: LG1	
4	In addition to score 3 performances, the students product can be entered into competitions.
3	The students can: • conceive and design a project; • develop a understanding of their chosen topic; • collaborate with team members; • meet the project specifications given; • create a functioning product; • set and re-evaluate short and long term goals consistent with achieving a functional final project.
2	The student project falls short of completion due to minor missteps during the process, or the final project fails to function due to minor design flaws.
1	The student project falls short of completion due to major lapses during the process, or the final project fails to function due to design flaws.
0	A lack of effort and industry caused the student to create no significant project.
LEARNING SCALE: CG2	
4	In addition to score 3 performances, the student can showcase their finished project in district wide presentation or in outside competitions.
3	The student can: • clearly state project long and short term goals; • present relevant information in a logical manner; • justify that sufficient progress has been made toward the stated goals; • demonstrate that research has been appropriately integrated into their work; • produce and use appropriate diagrams and graphs to clearly support and explain their work; • produce a presentation appropriate for a given target audience and time frame; • demonstrate appropriate use of language to clearly communicate progress and understanding; • document the work such that others can understand and reproduce it.
2	The student has made progress toward all score 3 performances and has demonstrated proficiency with the majority of them.
1	The student, with assistance, has made progress toward a majority of the score 3 performances.
0	Even with help, the student has not made significant progress toward the majority of the level 3 performances.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Researchers often have to change the direction of their project based on outside influences.	EQ1a: What outside influences can affect my project? EQ1b: What do I do if I realize my project is not heading in the right direction?
EU2: All research is potentially impacted by legal and ethical considerations.	EQ2a: How do I determine the ethical implications of my project? EQ2b: How do I know if my project is being done within the boundaries of the law?

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU3: Safety is a fundamental consideration in all research.	EQ3: If I am designing the research, how do I determine the safety considerations for myself and others?
EU4: Appropriately designed products meet the needs of the intended users.	EQ4a: What characteristics determine the usability of a product? EQ4b: How do I determine if my product meets the needs of the intended users?

NGSS & COMMON CORE STANDARDS

NGSS:

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.

CCSS:

HS.N.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.N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

11-12.RST.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.
11-12.RST.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
11-12.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades
11-12.RST.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.
11-12.RST.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.

11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
11-12.WHST.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
11-12.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
11-12.WHST.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
11-12.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.

ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1, CG2 EU1, EQ1a, b EU2, EQ2a, b EU3, EQ3 EU4, EQ4a, b HS-ETS1- 1, 2, 3, 4 HS.N.Q.A.1, 2 11-12.RST.4, 7 11-12.WHST.4, 7, 8 DOK 4	Students will develop a project proposal, set major long term goals, and outline a path to meet these goals. Students will then complete tasks collaboratively in order to reach their goals. Students will create a final project that they will showcase in a formal presentation. The presentation will include the research, the construction of the project, and any trouble shooting that occurred. Students will be assessed on the quality of the presentation, the quality of the final project, and the activities log book.

POSSIBLE RESEARCH PROJECT TOPICS
Astronomy Computer Interfacing Fluid Statics & Dynamics Laser Art & Communication Magnetic Forces & Fields Mathematical Models Robotics Alternative Energy and Environmental Concerns

ASTRONOMY	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: The night sky provides a snapshot of the evolution of the universe.	EQ1: How do we collect astronomical data for events that happened billions of years ago?
EU2: Evolving technologies have provided astronomers with many new tools for observing the universe.	EQ2a: How do you choose the best technology to provide the data you need? EQ2b: How do you compensate for the limitations of our current technology to provide the data you need? EQ2c: How have recent developments in technology influenced the field of astrophotography?
EU3: Astronomical observations can be used to investigate the very nature of the universe.	EQ3a: How do we make accurate astronomical observations? EQ3b: How can a mere observation help us understand the nature of the universe?
NGSS & COMMON CORE STANDARDS	
NGSS: HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	
SUGGESTED AREAS OF RESEARCH	
Evaluate the various types of specialized hardware and techniques for celestial viewing Construct a telescope or telescope mount Hand grind a telescope mirror Analyze astrophotographs using computer software Build and use a "solar" telescope to observe solar activity	

COMPUTER INTERFACING	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: One technological tool may be better than another to complete a specific task.	EQ1: How do I determine which technological tool to use, given the task?
EU2: The speed with which computers process information is limited by both the choice of computer platform and the robustness of the interface between the computer and the outside world.	EQ2a: Does speed really matter in the end? EQ2b: How do all my choices have consequences? EQ2c: What needs to be taken into consideration when deciding what operating system is best suited for a particular research application?
EU3: Computers can be used to model the physical world in ways that would otherwise be impractical or impossible.	EQ3a: How do I determine whether or not to use a computer simulation or the physical world? EQ3b: Does the method I use to communicate my model affect my message? EQ3c: Is there anything I can't model with a computer?
NJCCCS & COMMON CORE STANDARDS	
NGSS: HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.	
SUGGESTED AREAS OF RESEARCH	
Object identification and edge detection Text recognition Network communication Web-based services Automated weighing Vibration monitors Waveform analysis Effects processing Noise filtering Machine interpretation of handwriting Interpretation of 3-dimentional scenes Hand, head, arm, and body position sensing Sound cancellation system	

FLUID STATICS AND DYNAMICS	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: The flow of fluids is responsible for important phenomena in the natural world.	EQ1a: How can we determine whether a problem is amenable to analysis using fluid statics or fluid dynamics? EQ1b: What physical principles describe the behaviors of fluids? EQ1c: How can the principles of fluid statics and dynamics be used to account for weather phenomena?
EU2: Fluid flow can be generalized to many areas where its application may seem unlikely.	EQ2a: How are transportation systems influenced by fluid properties? EQ2b: How can the flow of fluids be used to explain occurrences in sports? EQ2c: How can controlling the flow of fluids be used for the benefit of mankind?
EU3: The properties of fluids are governed by the fundamental laws of physics.	EQ3a: What physical principles can be used to account for the behaviors of fluids both at rest and in motion? EQ3b: How do the behaviors of fluids at rest differ from fluids in motion?

NJCCCS & COMMON CORE STANDARDS

NGSS:

HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

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

SUGGESTED AREAS OF RESEARCH

Measure the volume of an irregularly shaped object using Archimedes' principle
Measure the density of solids through a variety of techniques
Measure the buoyancy force acting on an object floating and/or submerged in a liquid
Measure the density of fluid with a self-constructed hydrometer
Measure the surface tension and/or contact angle of a fluid through capillary action
Design, create, and use an open ended manometer to: measure the pressure in a moving fluid and/or measure the speed of a moving fluid
Calibrate a manometer by measuring the pressure at various depths of a static fluid of known density
Use a manometer to verify the Law of Continuity and verify the Venturi effect
Determine the validity of the Bernoulli equation
Verify Torricelli's theorem for moving fluids
Measure the terminal velocity of an object falling through a dense fluid and verify Stoke's law
Measure the frictional force acting on a variety of objects sitting in a moving fluid
Determine the Reynold's number for an object of a specific shape
Measure the frictional force acting on an object sitting in a moving fluid
Measure the lift force produced on a wing shaped object placed in a moving fluid.
Design variously shaped objects using appropriate computer software
Construct wing cross sections of various sizes and/or other objects and measure the resulting drag and lift

LASER ART AND COMMUNICATION	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: Lasers have had and will continue to have significant impact on the evolution of our culture.	EQ1a: Why have lasers become ubiquitous throughout our culture? EQ1b: In what ways has the potential of laser technology yet to be felt?
EU2: Due to the unique properties of laser light, lasers can perform tasks that are otherwise difficult or impossible.	EQ2: Why has the use of lasers become critical in certain fields?
EU3: Lasers can be used to create artwork.	EQ3a: In what ways have lasers crossed the boundaries of sciences into art? EQ3b: Do you consider laser art beautiful? Why?
NJCCCS & COMMON CORE STANDARDS	
HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information. HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.	
SUGGESTED AREAS OF RESEARCH	
Measure the wavelength of laser light Measure the beam divergence of a laser Shape beams using the Kogelnik criteria Split beams and measure the relationship between the two beams after traveling different paths Polarize laser light and manipulate the resulting beam Modulate the intensity of a laser beam and use the resulting beam to transfer information Measure the intensity of a laser beam using a photo multiplier tube Measure the speed of light as it passes through air by measuring the phase difference between two portions of a laser beam having traversed different paths Measure the speed of light through air through the uses of an interferometer Measure the speed of light through an optical cable by measuring the phase relationship between two different portions of the laser beam Produce a reflection or a transmission hologram using laser light Measure the speed of a moving object using a laser Create an optics based musical instrument using laser light Decode the barcodes used on most consumer products using a laser Design and complete a project that uses lasers in a unique and original application	

MAGNETIC FORCES AND FIELDS	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: Magnetic forces and fields have been responsible for much of the evolution of modern technology.	EQ1a: How is magnetism used in hidden ways? EQ1b: How does magnetism relate to other forces and phenomena in physics? EQ1c: How is magnetism used in new technologies?
EU2: Magnetic forces and fields are responsible for many unexpected effects.	EQ2a: How do magnetic fields interact with electric currents and moving charges to do work? EQ2b: How can physical laws be used to make predictions about interactions between fields and charged particles?
EU3: Some tasks can be performed more effectively by using the unique properties of magnetism.	EQ3a: How can properties of magnetic forces and fields be used to facilitate the conversion of one form of energy into another and to do useful work? EQ3b: How can magnetic materials be used as a medium for storing information?
NJCCCS & COMMON CORE STANDARDS	
NGSS: HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	
SUGGESTED AREAS OF RESEARCH	
Measure the magnetic force on a moving charged particle Measure the magnetic force between two current carrying wires Measure the magnetic force between a current carrying wire and a permanent magnet Measure the magnetic field strength in the vicinity of various sources of magnetic energy using a Hall effect probe Measure the torque produced on a current carrying loop Levitate an object using a system of permanent magnets Accelerate an object from rest using magnetic forces and fields Build an active levitation system using electromagnetism Build a model Maglev train Design and build a device that operates on the principle of magnetism	

MATHEMATICAL MODELS	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: Mathematical modeling is an invaluable tool for studying the various fields.	EQ1a: Can mathematics model everything in the universe? EQ1b: Why do we use models?
EU2: Mathematical modeling can be used to make future predictions based on data from the past, but these predictions can seem contrary to our everyday perception.	EQ2a: What affects the accuracy of a prediction? EQ2b: How can the quality of a prediction be evaluated? EQ2c: When is it appropriate to ignore mathematical predictions? EQ2d: When might intuitive methods be preferred over a prediction?
EU3: Systems can be modeled at several different levels of complexity.	EQ3a: What advantages and limitations arise from keeping a model simple? EQ3b: When is additional complexity in a model detrimental to the accuracy or utility of the model?
EU4: Mathematical modeling can be done using a variety of tools.	EQ4a: How do I determine the best technological tool to create my model? EQ4b: How can I best communicate the results of mathematical modeling to an audience?

NJCCCS & COMMON CORE STANDARDS

NGSS:

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

CCSS:

HS.A.REI.8 Represent a system of linear equations as a single matric equation in a vector variable.
HS.A.REI.9 Find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3 x 3 or greater).
HS.F.BF.1 Write a function that describes a relationship between two quantities.
HS.N.VM.3 Solve problems involving velocity and other quantities that can be represented by vectors.
HS.N.VM.6 Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network.
HS.N.VM.11 Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors.

SUGGESTED AREAS OF RESEARCH

Predict weather by analyzing weather patterns
Examine chaotic physical systems
Implement neural networks to `find Waldo'
Examine the relationship between topology and relativity
Model fractal systems
Simulate an ant colony
Examine self-organizing systems
Investigate machine translation of language
Investigate machine interpretation of language and/or handwriting
Simulate and optimize physical systems (e.g., a trebuchet)
Simulate gravitational interactions in multi-body systems
Analyze visual perception
Create and analyze statistical models

ROBOTICS	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: Robots have the potential to vastly improve the lives of the physically disabled.	EQ1a: How do you determine which disabilities can be assisted with robotic tools? Will that change as technology advances? EQ1b: What societal and social implications arise from technological aids for the disabled?
EU2: Robots can complete tasks that are impossible, too repetitive, or too dangerous for humans to perform.	EQ2a: What societal implications come about from augmenting or replacing humans with robotic devices? EQ2b: What criteria need to be evaluated in determining the suitability of automating a task?
EU3: Mathematical systems, electronic systems, computer models, and mechanical systems work together in any practical robotic system.	EQ3a: How do mathematics, electronics, mechanics, and computer programming all interact in a robotic system? EQ3b: If the robotic system isn't working, how do you know what went wrong?

NJCCCS & COMMON CORE STANDARDS

NGSS:

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1)increases in the number of individuals of some species, (2)the emergence of new species over time, and (3) the extinction of other species.
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

SUGGESTED TOPICS

Micro-positioning system
Robot that can play games (e.g., tic-tac-toe, ping pong)
A mechanical device, such as a gripper arm, that follows the movements of a human limb
Robot that performs a task (e.g., maintains orientation relative to a moving target, automated 3-D craving or modeling, painting, balancing)
Robot that explores (e.g., self-navigating all-terrain vehicle, mobile root for exploration of an environment)

ALTERNATIVE ENERGY AND ENVIRONMENTAL CONCERNS	
POSSIBLE ENDURING UNDERSTANDINGS	POSSIBLE ESSENTIAL QUESTIONS
EU1: Energy sources can be developed that produce smaller environmental impacts, but there are tradeoffs for each practical energy source.	EQ1a: How do we measure the environmental impact of an energy source? EQ1b: How do we determine if using a new energy source is the right thing to do?
EU2: There are various means of transporting and using energy, and each has its own costs and benefits.	EQ2: How do you balance the benefits and costs of various methods of storing and transporting energy?
EU3: The impacts and economies of central supply can be balanced against local supply for different applications.	EQ3: How do we decide whether central supply and distribution, local sourcing, or a hybrid approach is best for a particular application?
EU4: Human activities impact the environment, and these environmental impacts affect human life.	EQ4: How can we predict the direct, indirect, and potential impacts of various conventional and alternative energy sources?

NJCCCS & COMMON CORE STANDARDS

NGSS:

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

SUGGESTED TOPICS

Construct a photovoltaic device and/or analyze the removal of waste heat from photovoltaic systems
Use fuel cell technology in a mobile device
Create a working geothermal heating or cooling system
Create a device that makes use of a sterling engine
Create a working desalination system
Create a simulation of hydraulic fracking
Create models of the greenhouse gas emission in landfills and/or develop natural gas recovery system for landfills or compost pile