Randolph Township Schools
Randolph High School

Physics and Engineering: Engineering Curriculum

"I have not failed. I've just found 10,000 ways that won't work."
- Thomas Alva Edison

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Randolph Township Schools
Department of Science, Technology, Engineering, and Math

Physics and Engineering: Engineering

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Randolph Township Schools

Mission Statement

We commit to inspiring and empowering all students in Randolph Schools to reach their full potential as unique, responsible and educated members of a global society.

Randolph Township Schools
Affirmative Action Statement

Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum addresses the elimination of discrimination and the achievement gap, as identified by underperforming school-level AYP reports for state assessments. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

RANDOLPH TOWNSHIP BOARD OF EDUCATION
EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

Randolph Township Schools
Department of Science, Technology, Engineering, and Math

Introduction

Randolph Township Schools is committed to excellence. We believe that all children are entitled to an education that will equip them to become productive citizens of the 21st century. We believe that an education grounded in the fundamental principles of science, technology, engineering, and math (STEM) will provide students with the skills and content necessary to become future leaders and lifelong learners.

A sound STEM education is grounded in the principles of inquiry, rigor, and relevance. Students will be actively engaged in learning as they use real-world STEM skills to construct knowledge. They will have ample opportunities to manipulate materials and solve problems in ways that are developmentally appropriate to their age. They will work in an environment that encourages them to take risks, think critically, build models, observe patterns, and recognize anomalies in those patterns. Students will be encouraged to ask questions, not just the "how" and the "what" of observed phenomena, but also the "why". They will develop the ability, confidence, and motivation to succeed academically and personally.

STEM literacy requires understandings and habits of mind that enable students to make sense of how our world works. As described in Project 2061's *Benchmarks in Science Literacy, The Standards for Technological Literacy,* and *Professional Standards for Teaching Mathematics,* literacy in these subject areas enables people to think critically and independently. Scientifically and technologically literate citizens deal sensibly with problems that involve mathematics, evidence, patterns, logical arguments, uncertainty, and problem-solving.

Physics and Engineering: Engineering

Introduction

The Engineering half of Physics and Engineering is designed to apply the concepts taught in Physics. A variety of challenging, hands-on activities and projects will lead the learner to a greater understanding of how engineers apply the theoretical concepts of physics in the design and construction of real-world solutions to real-world problems.

In addition to the topics covered in the Physics class, other theoretical ideas will also be explored in the areas of hydrodynamics, acoustics, mechanical strength and structure.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
2 weeks and ongoing	I	Introduction to Engineering
1 week and ongoing	II	Safety
12 weeks	III	Vectors, Kinematics, Newton's Laws: Canoe Project
12 weeks	IV	Momentum, Circular Motion, Rotational Mechanics: Human-Powered "Hamster Wheel" Generator Project
12 weeks	V	Center of Gravity, Universal Gravitation, Energy: Rube Goldberg Project
12 weeks	VI	Mechanical Waves and Sound: Electric Guitar Project

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering
UNIT I: Introduction to Engineering

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS	
There are design tools, which can, like any other type of tool, extend and improve our ability to accomplish goals.	• What do you do when defined procedures don't work, or when there are no defined procedures to begin with?	
All real world design solutions are created in a context of parameters and special considerations: most of these concern a human element.	• Under what circumstances does the human element remain indispensable to the engineering design process?	
KNOWLEDGE	**SKILLS**	**NJCCCS**
Students will know: The Engineering Design Process consists of: Identifying a problem Framing a Design Brief Conducting research Generating multiple possible solutions Selecting a "best" solution by providing a rationale Planning the implementation of the solution Prototyping Testing and evaluating	**Students will be able to:** Create sketches and drawings to accurately portray design ideas for self-designed projects. Construct working models and finished projects which meet quality standards for fit and finish.	<u>NJCCC Science:</u> 5.1.12.C.1 5.3.12.A 5.3.12.B.1 5.4.12.C.1 <u>NJCCC Technology:</u> 8.2.12.B.1-3 8.2.12.B.5 9.4.12.0 9.4.12.(1) 9.4.12.(2)
Accurate recordkeeping and documentation are vital to the engineering design process.	Write and maintain an accurate and organized engineering journal.	<u>Common Core Math:</u> HSG-CO.A.1 HSG-CO.A.5 HSG-CO.D.12 HSG-MG.A.3
Design and engineering are disciplines, which have expectations about strong work habits, a collaborative spirit, safe work habits, a lively curiosity, and a sense of responsibility to our shared culture, planet, and resources.	Demonstrate cooperative, productive, diligent work ethic in the completion of tasks. Employ brainstorming techniques to develop creative ideas and design solutions. Collaborate with team members to achieve specified goals.	<u>Common Core ELA:</u> RST.9-10.4 RST.11-12.4 WHST.9-10-7 WHST.11-12.7
Design elements such as balance, harmony, color, strength, and "user-friendliness" must be given due weight.	Employ color, balance, and harmony as integral parts of a pleasing design.	

Ergonomic factors such as typical seat height, arm reach, and field of vision play a key role in virtually all designed products. Structural considerations of mass, rigidity or flexibility, ease of motion (or not), and “buildability” inhere in effective designs.	Evaluate proposed designs in terms of ergonomic comfort and efficiency. Appraise self-designed engineering solutions in terms of the application and control of forces both static and dynamic.	

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Unit I-Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
2 Weeks and ongoing	**Unit I- Introduction to Engineering** **Personal Responsibilities in the Workplace**	
	Keeping an Engineering Journal	Resources: **Teacher generated handouts, Power Point slides, demonstrations** **SUGGESTED ACTIVITIES:** **Canoe Project** **Trebuchet Project** **Electric Guitar Project** **Human-Powered "Hamster Wheel" Generator Project** **Recycled Cardboard Project** **Rube Goldberg Project**
	The Design Loop	
	The Artist's Toolkit: Visual Elements and Principles	
	Steps in the Design, Documentation, and Model Making Process	
	Design Considerations and Parameters	
	Sketching and Drawing	
	Working with Hand Tools	
	Working with Power Tools	
	Gluing and Adhesives	
	Characteristics of Materials	

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering
UNIT II: Safety

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS	
Following proper safety measures will ensure a healthy working environment.	• In what ways has "personal safety" changed in the workplace?	
Maintaining the workspace in a neat, safe condition helps to protect the user from injury and enhances the quality of the finished product.	• What is the value of responsibility?	
KNOWLEDGE	**SKILLS**	**NJCCCS**
Students will know: Correct safety procedures to follow when using tools include wearing safety glasses. Correct safety procedures to follow when using hand tools include making sure blades are sharp, cutting away from oneself, securing the work properly, and using tools only for their intended function. Correct safety procedures to follow when using power equipment include wearing safety glasses, making sure blades are sharp, keeping hands a safe distance from moving parts, and making sure areas around machines are clear. Correct safety procedures to follow when using soldering irons and electric power supplies include wearing safety glasses, having all equipment ready, and clearing work area of unneeded materials.	**Students will be able to:** Demonstrate safe practices by wearing safety glasses at all appropriate times. Use hand and power tools found in the lab safely and responsibly. Operate soldering equipment and electrical power supplies in a safe, energy-conserving manner.	**Science:** 5.1.12.C.1 5.1.12.C2

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Unit II-Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
1 Week and ongoing	**Unit II- Safety**	
	Wearing Safety Glasses	**Resources:** **Teacher generated handouts, demonstrations** **SUGGESTED ACTIVITIES:** **Ongoing observation of safe, responsible procedures at all times in the lab**
	Safe use of Hand Tools	
	Safe Use of Power Tools	
	Safe Procedures for Soldering Equipment and Electrical Power Supplies	

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering
UNIT III: Vectors, Kinematics, Newton's Laws: Canoe Project

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
The overall dimensions, contours, and proportions of a watercraft have a profound effect on carrying capacity, maneuverability, speed, and comfort.	• How do the physical elements of a watercraft act in harmony to produce a design, which meets the functional and aesthetic qualities specified by the designer?
The overall dimensions, contours, and proportions of a watercraft also enable it to stay afloat under adverse conditions, and move through the water easily and efficiently.	• How are such factors as buoyancy, drag, and displacement factored into the design of a specific type of watercraft?
The physical properties desirable in an efficient, useful, comfortable canoe are achieved through the application of specific tools, materials, and processes.	• In what ways can readily available materials be made to work together to construct a light, strong, rigid, watertight craft?

KNOWLEDGE	SKILLS	CCSS
Students will know:	**Students will be able to:**	
How to convert English to metric measurements and *vice versa.*	Convert between English and metric measurements to construct an accurate scale model of a canoe from a given plan.	NJCCC Science: 5.1.12.C.1 5.3.12.A 5.3.12.B.1 5.4.12.C.1
Basic Physics concepts applicable to the "Canoe Project" and definitions of the following boat building terms: bow, stern, stem, thwart, gunwale, breasthook, sheer-line, waterline, rocker, wetted surface, tumblehome, recurve, and entry line.	Use a variety of hand and power tools to construct a canoe, from a given plan, which is watertight, capable of carrying two passengers comfortably, and handles properly in still water.	NJCCC Technology: 8.2.12.B.1-3 8.2.12.B.5 9.4.12.0 9.4.12.(1) 9.4.12.(2)
The following physics terms: displacement, friction, drag, and buoyancy.	Define and calculate the friction (drag) on a wetted surface. Define and calculate the displacement of a watercraft. Define and calculate the buoyancy of a watercraft.	Common Core Math: HSG-CO.A.1 HSG-CO.A.5 HSG-CO.D.12 HSG-MG.A.3 Common Core ELA: RST.9-10.4 RST.11-12.4 WHST.9-10-7 WHST.11-12.7

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Unit III - Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
12 weeks	**UNIT III: Vectors, Kinematics, Newton's Laws: Canoe Project** **Converting between English and metric units** **Laying out, cutting, and forming a design in balsa wood** **Lofting: transferring a design from plan to plywood** **Stitch and glue construction** **Fabricating gunwales, seats, breasthooks** **Applying fiberglass to a compound surface** **Appling paint** **Water safety and control of a canoe** **Calculating drag on a wetted surface** **Calculating buoyancy** **Comparing drag on different hull designs** **Testing and evaluation of finished craft**	**Teacher generated handouts, Power Point slides, demonstrations** **<u>SUGGESTED ACTIVITIES:</u>** **Canoe Project**

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering
UNIT IV- Momentum, Circular Motion, Rotational Mechanics: Human-Powered "Hamster Wheel" Generator Project

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
The rotational energy of a generator wheel directly relates to the electrical energy generated.	• What are some important factors that must be considered when constructing a turbine?

KNOWLEDGE	SKILLS	CCSS
Students will know: The following physics terms: rotation, revolution, period, frequency, centripetal force, centripetal acceleration, rotational inertia, and torque. The larger the radius of a disk and the more massive the disk, the more rotational inertia it has. This inertia can be employed to generate electrical power. The amount of energy a generator can produce is always less than the amount put into it. Energy is equal to power exerted over a period of time and may be calculated in an electric circuit.	**Students will be able to:** Design and construct a wheel supported by a rigid chassis capable of being operated by a student of average height to power a generator. Create a generator system which interfaces with the above wheel and which through a voltage regulator is capable of charging a cell phone with the generated power. Create an artifact that details how much electrical energy in kilowatt hours would be saved if every student in the school charged their cell phone once using the finished device (to be completed at the end of Unit VI).	<u>NJCCC Science:</u> 5.1.12.C.1 5.3.12.A 5.3.12.B.1 5.4.12.C.1 <u>NJCCC Technology:</u> 8.2.12.B.1-3 8.2.12.B.5 9.4.12.0 9.4.12.(1) 9.4.12.(2) <u>Common Core Math:</u> HSG-CO.A.1 HSG-CO.A.5 HSG-CO.D.12 HSG-MG.A.3 <u>Common Core ELA:</u> RST.9-10.4 RST.11-12.4 WHST.9-10.7 WHST.11-12.7

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Unit V - Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
12 weeks	**UNIT IV- Momentum, Circular Motion, Rotational Mechanics: Human-Powered "Hamster Wheel" Generator Project** Design and construct wheel Design and build chassis Create generator system Deploy generated power to charge cell phone Predict and then measure how much electrical energy in kilowatt hours would be saved if every student in the school charged their cell phone once using the finished device	**Teacher generated handouts, Power Point slides, demonstrations** **<u>SUGGESTED ACTIVITIES:</u>** **Human-Powered "Hamster Wheel" Generator Project**

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering
Unit V- Center of Gravity, Universal Gravitation, Energy: Rube Goldberg Project

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
"To invent, you need a good imagination and a pile of junk." Thomas Edison.	• Where do the insights, which result in innovation, come from?
Energy can never be created or destroyed, but it can be transferred from one form to another.	• How does energy move from place to place, and form to form, in order to accomplish tasks?

KNOWLEDGE	SKILLS	CCSS
Students will know: Energy can take many forms, *e.g.* potential, kinetic, elastic, electrical. In order to transfer energy, work must be done. In the real world, there will always be energy lost due to friction; the energy lost is converted to heat energy.	**Students will be able to:** Design and construct a device which transfers energy from one form to another by meeting the design challenge as stated in the Rube Goldberg Machine Contest. The specific task will change from year to year, but the following rules will always apply: A minimum of 20 steps in the process (no maximum number of steps), a maximum size of 6' x 6' x 6', compressed air and electrical power may be used. No explosives, hazardous materials, electric arcing, or animals (living or dead) may be used. The device must be safe for participants and observers. Determine the work required for a variety of energy transfers in a constructed device. Predict the total energy lost to thermal energy from the operation of a constructed device.	<u>NJCCC Science:</u> 5.1.12.C.1 5.3.12.A 5.3.12.B.1 5.4.12.C.1 <u>NJCCC Technology:</u> 8.2.12.B.1-3 8.2.12.B.5 9.4.12.0 9.4.12.(1) 9.4.12.(2) <u>Common Core Math:</u> HSG-CO.A.1 HSG-CO.A.5 HSG-CO.D.12 HSG-MG.A.3 <u>Common Core ELA:</u> RST.9-10.4 RST.11-12.4 WHST.9-10.7 WHST.11-12.7

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Unit V - Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
12 weeks	**Unit V- Center of Gravity, Universal Gravitation, Energy: Rube Goldberg Project** **Design and construct a device which transfers energy from one form to another by meeting the design challenge as stated in the Rube Goldberg Machine Contest.** **Determine the work required for a variety of energy transfers in a constructed device.** **Predict the total energy lost to thermal energy from the operation of a constructed device.**	**Teacher generated handouts, Power Point slides, demonstrations** **<u>SUGGESTED ACTIVITIES:</u>** **Rube Goldberg Project**

RANDOLPH TOWNSHIP SCHOOL DISTRICT
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UNIT VI: Mechanical Waves and Sound: Electric Guitar Project

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS	
The principles by which amplified musical instruments work are defined by electronics, acoustics, mechanical engineering, mathematics, and an ineffable human, artistic component.	• How can one understand in a methodical, reasoned way the confluence of technologies and the human element that defines the essence of music as exemplified by the electric guitar?	
KNOWLEDGE	**SKILLS**	**NJCCCS**
Students will know: The following terms: voltage, current, resistance, power, resistors, capacitance, capacitor, potentiometer, induction, amplification, microchip. Acoustic signals can be changed into electronic signals, and *vice versa*. The tension on strings, which produce well-modulated sound waves, is a force that needs to be compensated for in the design of a musical instrument. Standing waves relate to the frequency (pitch) of a tone. There is an inverse relationship between wavelength and pitch of sound waves.	**Students will be able to:** Breadboard an amplifier circuit from supplied components. Design and create a mechanical device to produce coils of wire with accuracy and neatness, then use those coils to fabricate a device that transduces acoustic waves to electronic signals. Assemble an electronic circuit capable of amplifying electronic signals. Develop a plan for a complex musical instrument capable of withstanding the forces of steel strings under tension. Demonstrate a strong working knowledge of the laws of physics as they apply to self-designed engineering solutions. Construct an electric guitar tuned to concert pitch (A=440 Hz) capable of playing one octave.	<u>NJCCC Science:</u> 5.1.12.C.1 5.3.12.A 5.3.12.B.1 5.4.12.C.1 <u>NJCCC Technology:</u> 8.2.12.B.1-3 8.2.12.B.5 9.4.12.0 9.4.12.(1) 9.4.12.(2) <u>Common Core Math:</u> HSG-CO.A.1 HSG-CO.A.5 HSG-CO.D.12 HSG-MG.A.3 <u>Common Core ELA:</u> RST.9-10.4 RST.11-12.4 WHST.9-10.7 WHST.11-12.7

Musical scales are contrived, not derived. Octaves are based on the twelfth root of two. Musical frequencies can be measured and analyzed via computer software (e.g., Audacity).		

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Unit IV - Curriculum Pacing Chart
Physics and Engineering: Engineering

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
12 weeks	**UNIT VI: Mechanical Waves and Sound: Electric Guitar Project** **Introduction to electricity and electronics** **Design a mechanism to wind pick-up coils** **Research, design, and "breadboard" an amplifier circuit** **Develop a plan for a solid body electric guitar** **Construct the guitar based upon plans** **Install frets, electronic components, apply finish and "fine tune" the guitar**	**Teacher generated handouts, Power Point slides, demonstrations** **<u>SUGGESTED ACTIVITIES:</u>** **Electric Guitar Project**

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering

APPENDIX A

RESOURCES:

Technology:

- Software capable of measuring and analyzing sound waves, such as Audacity
- Spreadsheet software such as Excel
- Word processor software such as Word
- Presentation software such as Powerpoint
- Image manipulation software such as Imagej

Web addresses:

- Capacitor code information: http://www.csgnetwork.com/capcodeinfo.html
- Guitar pickup construction: http://www.instructables.com/id/Make-A-Guitar-Pickup/
- Canoe construction: http://www.bateau2.com/
- Concrete canoe: https://sites.google.com/site/njitconcretecanoe/
- Rube Goldberg contest: http://www.rubegoldberg.com/?page=home
- http://www.sciencetoymaker.org/
- Human hamster wheel: http://www.youtube.com/watch?v=szGrg4GfpVQ
- *Et al*

APPENDIX B

ASSESSMENT:

- Quiz
- Test
- Individual Projects
- Group Projects
- Homework
- Online Resources

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APPENDIX C

Opportunities exist for interdisciplinary units with courses such as AP Environmental Science, Advanced Woodworking, and other STEM electives.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Physics and Engineering: Engineering

APPENDIX D

It is assumed that the student has successfully completed Algebra I, Geometry and Algebra II.

APPENDIX E

Lesson plans to follow as curriculum is implemented.