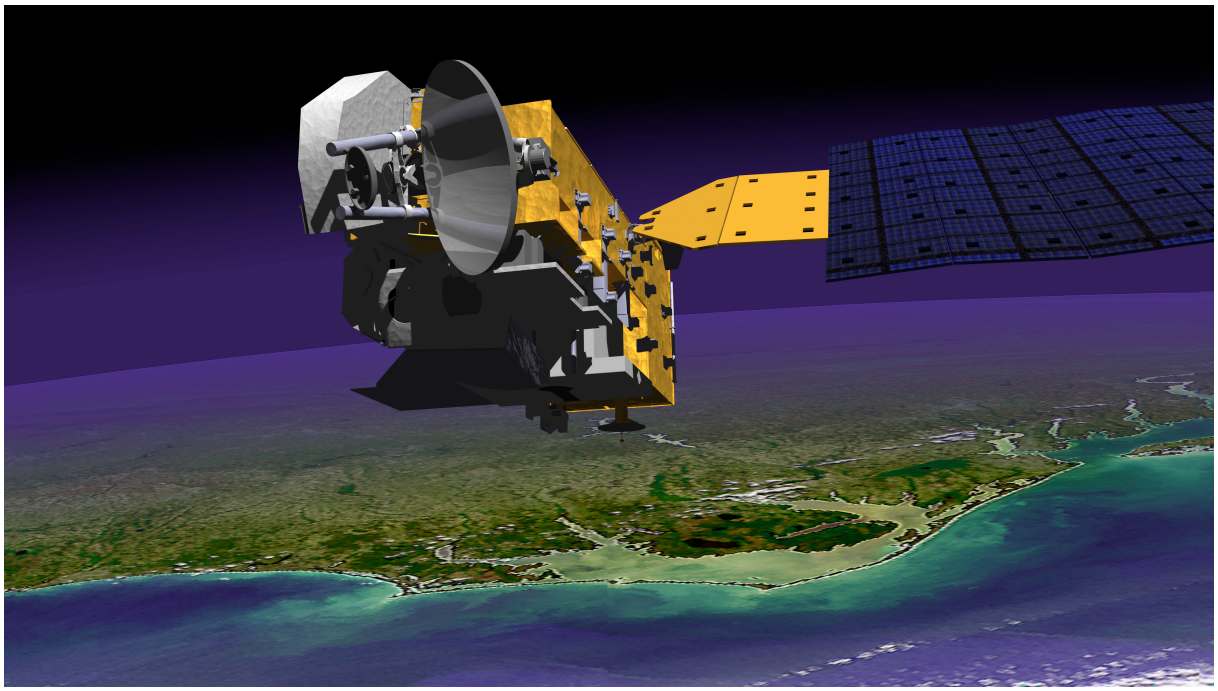
Sensors, Circuits, and Satellites
Teacher's Guide



Sensors, Circuit, and Satellites is a collection of classroom lessons created by NASA's Aura mission education and outreach that explore the electromagnetic spectrum and NASA remote sensing instruments using student assembled circuits. These lessons integrate inquiry with active-learning experiences to engage students in the properties of electromagnetic energy and remote sensing. The investigations are sequenced to help the learner construct their knowledge about the electromagnetic spectrum while offering real world examples from NASA.

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The properties and characteristics of electromagnetic energy are fundamental to all NASA missions and their science. NASA's scientific instruments onboard spacecraft and airplanes collect data on how electromagnetic waves behave when they interact with matter. Electromagnetic energy travels in waves and spans a broad spectrum from very long radio waves to very short gamma rays. The human eye can only detect only a small portion of this spectrum called visible light. NASA's scientific instruments use the full range of the electromagnetic spectrum and these data can reveal the physical and chemical composition of matter to help scientists study the Earth, the solar system, and the universe beyond. For background on the Electromagnetic Spectrum, visit http://missionscience.nasa.gov/ems/

These lessons are designed to integrate inquiry with active-learning experiences to engage students in the properties of electromagnetic energy and remote sensing. The investigations are sequenced to help the learner construct their knowledge about energy and the electromagnetic spectrum while offering real world examples from NASA.

The lessons compiled in this guide were developed using electronics developed by littleBits Electronics, but each lesson includes a list of alternate materials. A companion set of activities are available online in the littleBits™ Space Kit booklet and includes five activities that investigate energy and the properties of waves and five build projects that demonstrate NASA technology (satellite orbits, space grappling device, Mars rovers) and basic science principles with math connections such as the speed of light (star chart projector) and parabolic reflectors (satellite dish). These build activities have supplemental math activities.

Note about Materials:

The Sensors, Circuits and Satellites' lessons were developed in collaboration littleBits™ Electronics by NASA educators. The littleBits™ components are open-source and schematics for the components can be found at https://github.com/littlebitselectronics/eagle-files . Alternative materials to conduct these lessons are listed within the lessons under alternate materials.

Regarding Safety: The components used in these lessons are manufactured by littleBits components have passed product safety testing by Anseco Group, an independent accredited laboratory registered with the U.S. Consumer Product Safety Commission, for general use Educational Science Kits for ages 8+. For additional information regarding safety, please contact littleBits via their web site at http://www.littlebits.com/

Description of Lessons

Lesson 1: Wave Generator
This lesson uses sound to demonstrate how energy travels waves. Students will investigate sound energy created by vibrations of a speaker and visibly experience the energy as vibrations create waves in a liquid. Concepts of wavelength and frequency are introduced.

Lesson 2: Energy Meter
This lesson introduces students to light as a form of energy, different than sound. The investigation will lead to discovering existence of energy (light) we can't see as an introduction to the broader electromagnetic spectrum.

Lesson 3: Measuring the Atmosphere
This lesson is a demonstration about the scattering of light waves. Students will investigate how scattering occurs when light reflects off an object in different directions. Students will observe a simulation of how light waves are affected when traveling through the atmosphere. Concepts of behaviors of light including scattering, absorption, and transmission are introduced.

Lesson 4: Digital Communications
This lesson is a demonstration about electromagnetic energy and how that energy is transferred via visible and IR light waves to sound energy (digital signals). Students will investigate how the length of the wave affects how light energy is transmitted. Concepts of digital signal, visible, infrared or microwave waves are introduced.

Next Generation of Science Standards

The Next Generation of Science Standards were finalized in April 2013 based on the National Research Council's (NRC) Framework for K-12 Science Education. The Framework describes a vision of what it means to be proficient in science and presents three dimensions that will be combined to form each standard:

- Dimension 1: Practices
- Dimension 2: Crosscutting Concepts
- Dimension 3: Disciplinary Core Ideas

In the following lessons, middle school students will continue to develop understanding of the 8 practices of science and engineering and demonstrate understanding of the core physical science ideas of waves, energy and the electromagnetic spectrum. These investigations will include students developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations and several of the engineering practices including design and evaluation. These 8 practices are inherent within each lesson by design. (reference sidebar "8-practices")

Related crosscutting concepts are stated at the start of each lesson. These have application across all domains of science. As such, they are a way of linking the different domains of science such as patterns and structure and function. The Framework emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world.

Disciplinary core ideas focus the K–12 science curriculum, instruction and assessments on the most important aspects of science. Of the four domains of disciplinary ideas these lessons address ideas within the physical sciences - specifically waves and electromagnetic radiation. Additionally, they provide context to how these concepts are used by scientists in the earth and space sciences. Inherent to the companion build projects (activities 6-10 in the littleBits ™ Space kit) are connections to engineering, technology and applications of science.

At the middle school level, the PS4 Disciplinary Core Idea from the NRC Framework is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Within the performance expectations in the topic Waves and Electromagnetic Radiation, students formulate an answer to the question, "What are the characteristic properties of waves and how can they be used?" (see "Wave Generator" and "Energy Meter" lessons). Students are able to describe and predict characteristic properties and behaviors of waves when the waves interact with matter (see "Measuring the Atmosphere" lesson). Students can apply an understanding of waves as a means to send digital information (see "Digital Communication" lesson). The crosscutting concepts of patterns and structure and function are used as organizing concepts for these disciplinary core ideas and are address in the lessons with digital

signals, spectral signatures, and wave properties. These performance expectations focus on students demonstrating proficiency in developing and using models, using mathematical thinking, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

8 Practices in Next Gen Science and Engineering Standards

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

National Research Council. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press, 2012.

These lesson plans approach teaching the Next Generation Science Standards using the 5-E constructivist model. Each lesson is structured such that students can explore and construct their own understanding of the concepts.

Engage: capture students' attention and recall prior knowledge

Explore: activity to introduce concept, an investigation

Explain: discussion of concept, analysis of their exploration

Extend: apply concept to real world situation, expand their understanding

Evaluate: a short activity to assess students' understanding

Through these lessons are intended for grades 5-8, we encourage you to customize the activities to fit your class and curriculum. Depending on your students' prior knowledge, you may choose to expand or omit certain activities. We hope these investigations enable you to introduce new and exciting science concepts to your students. Happy exploring.