Exploring Robotics with Electronics Curriculum Physical Science Standards

Physical Science Standards obtained from Florida http://www.floridastandards.org. Most states have adopted similar standards.

References below each standard are to Presentation Discussion Questions or Quiz Questions, Boe-Bot Activities, or Simulator Activities in the curriculum Exploring Robotics with Electronics: An Introduction to Electronics with Boe-Bot.

For each of the standards, we recommend that the Boe-Bot material be used as examples to reinforce material covered in Physical Science textbooks, and that additional worksheet examples be provided for practice. The Boe-Bot robot provides an excellent hands-on example for application of theory, and will assist students in understanding the relevance of the material.

Energy

SC.912.P.10.1: Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.

Batteries represent conversion of chemical to electrical energy. Convert electrical energy to light – LEDs and IR. Electrical energy converted to magnetic energy – servo motors. Magnet energy converted to mechanical energy for motion. Mechanical energy converted to heat which is wasted.

SC.912.P.10.13: Relate the configuration of static charges to the electric field, electric force, electric potential, and electric potential energy.

Discussion of batteries and electrical circuits.

SC.912.P.10.14: Differentiate among conductors, semiconductors, and insulators.

Boe-bot wiring, resistors, wiring, transistors.

SC.912.P.10.15: Investigate and explain the relationships among current, voltage, resistance, and power.

Ohms law and learning resistor color codes.

SC.912.P.10.16: Explain the relationship between moving charges and magnetic fields, as well as changing magnetic fields and electric fields, and their application to modern technologies.

Discussion of how batteries and motors work.

SC.912.P.10.17: Explore the theory of electromagnetism by explaining electromagnetic waves in terms of oscillating electric and magnetic fields.

Discussion of Wireless radio controlled ROVs.

SC.912.P.10.18: Explore the theory of electromagnetism by comparing and contrasting the different parts of the electromagnetic spectrum in terms of wavelength, frequency, and energy, and relate them to phenomena and applications.

Infrared application in IR proximity sensors and IR remote for Boe-Bot.

SC.912.P.10.19: Explain that all objects emit and absorb electromagnetic radiation and distinguish between objects that are blackbody radiators and those that are not.

Discussion of Infrared Cameras used in night vision – used on ROVs and automated vehicles.

SC.912.P.10.2: Explore the Law of Conservation of Energy by differentiating among open, closed, and isolated systems and explain that the total energy in an isolated system is a conserved quantity.

Boe-bot activity – pushing an object and causing it to move – transferring energy from one object to another.

SC.912.P.10.21: Qualitatively describe the shift in frequency in sound or electromagnetic waves due to the relative motion of a source or a receiver.

Discussion of Sonic receivers and transmitters in underwater ROVs. Doplar Effect in sound.

SC.912.P.10.3: Compare and contrast work and power qualitatively and quantitatively.

Definition of work and power. Calculating horsepower. Description of Boe-bot movement.

SC.912.P.10.4: Describe heat as the energy transferred by convection, conduction, and radiation, and explain the connection of heat to change in temperature or states of matter.

Discussion of Night vision lenses and cameras used on ROVs. Motor heat. Infrared sensor detecting temperature.

SC.912.P.10.6: Create and interpret potential energy diagrams, for example: chemical reactions, orbits around a central body, motion of a pendulum.

Voltage represents potential energy. Interpret the change in energy as current moves through a circuit. Mechanical energy – robot arm moving like a pendulum and throwing an object.

SC.912.P.10.7: Distinguish between endothermic and exothermic chemical processes.

Recharging batteries is an endothermic process.

SC.912.P.10.8: Explain entropy's role in determining the efficiency of processes that convert energy to work.

Motors and the amount of heat generated and the waste energy. Monitoring temperature of Boe-bot motors over time while running.

Motion

SC.912.P.12.3: Interpret and apply Newton's three laws of motion.

Motors and motion of boe-bot. Measure how much energy it takes to get it to move.

SC.912.P.12.2: Analyze the motion of an object in terms of its position, velocity, and acceleration (with respect to a frame of reference) as functions of time.

Ball rolling down an incline plane (use the Boe-bot ball and use the electronic circuit to measure speed). Discussion after video on end effectors. End effectors on industrial robots throwing an object.

SC.912.P.12.4: Describe how the gravitational force between two objects depends on their masses and the distance between them.

Boe-bot grows up and becomes a rover on earth. Weight is 5X as big as now and we know it's weight, How much will it weigh on the moon? How much will it weigh on Mars? Moon is 1/6 the

size of earth. If Boe-bot was on a satellite – know the mass of the satellite, calculate the gravitational force of the satellite.

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SC.912.P.12.5: Apply the law of conservation of linear momentum to interactions, such as collisions between objects.

Boe-bot running into an object. Calculate mass of Boe-Bot. Calculate mass of the object to be hit. Calculate the speed of Boe-bot. Predict what will happen when it hits the object of a given mass.

SC.912.P.12.6: Qualitatively apply the concept of angular momentum.

Add a dish on top of Boe-Bot with a ball in the dish. Ball will move toward outside as Boe-bot spins in a circle.

SC.912.P.12.8: Recognize that Newton's Laws are a limiting case of Einstein's Special Theory of Relativity at speeds that are much smaller than the speed of light.

Discussion after covering Newton's law.

Chemical Reactions and Periodic Table

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

During discussion of Microcontrollers and electronics, assign an additional research report on defining the elements often used in electronics and cell phones, and mapping to the Periodic Table.

Types of Reactions (Ionic and Covalent)

Discussion of circuits and flow of energy through circuits from batteries. Include additional information to introduce the Ionic and Covalent reactions which pertain to electronics. This resource can assist: http://www.allaboutcircuits.com/textbook/direct-current/chpt-11/electron-activity-chemical-reactions/

Balancing chemical equations

During discussion of batteries and energy flow, introduce the chemicals used to make batteries. During discussion of how to balance chemical equations, use voltaic cells and the chemical reaction which occurs in batteries as an example. This resource can assist:

http://chemwiki.ucdavis.edu/Analytical_Chemistry/Electrochemistry/Voltaic_Cells/Case_Study%3A_Battery_Types/Batteries%3A_Electricity_though_chemical_reactions

Math

(Note: Additional math standards are met that have NOT been included here.)

MACC.912.A-REI.2.3: Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Motion and Speed and Acceleration: Rotational Speed of servo motor = frequency x coefficient

MACC.912.A-REI.2.4: Solve quadratic equations in one variable.

Power in an electrical circuit = IR_2 Ohms law – solve for power. Other formulas involving capacitor charge and discharge rates.

MACC.912.A-REI.3.6: Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

Multi-axial robotic arms – solving for the Cartesian position of an end effector.

Measurement and Metric Units

During calculations of speed of robot, students measure distance moved and calculate distance versus speed. Require that metric units be included in the table.