Course Description:
This course provides an introduction to the engineering process and a solid foundation in Robotics. The course uses the LEGO Mindstorms platform and the Carnegie-Mellon University developed curriculum. Students will work in small teams to design, build, test and program their robots.
Student will used the LEGO NXT programming language as well as the more advanced RobotC to allow their robots to navigate various obstacles courses and other challenges. The robots will employ a variety of sensors – touch, ultrasonic, sound, light and motor counters to enable the robots to react to and sense their environment. Through these activities, students will learn about safety, programming, the engineering process, teamwork, project management, problem solving, and other important skills

Student Targets:
By the end of this course…

- I will know how to maintain and personalize a robotics portfolio per guidelines given by the instructor.
- I will be able to make the connection that robotics is a multidisciplinary subject.
- I will be able to interpret the building instruction sheets of various robots.
- I will expand my vocabulary of terms related to robotics.
- I will be able to relate basic concepts of physics and simple machines to their study of robotics.
- I will be able to describe how the field of robotics is incessantly evolving.
- I will be able to collaborate in small groups constructing, programming and troubleshooting robots.

Standards: *STEM Standards for Robotics are drawn from NSS (National Science Standards), NCTM (National Council of Teachers of Mathematics), and ITEA (International Technology Educators Association).*

Math Standards addressed: (from the Common Core Standards)

CCSS.Math.Content.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. CCSS.Math.Content.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. CCSS.Math.Content.HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	Robotics uses *NUMBERS AND OPERATIONS* in nearly all lessons, for example: • Calculating distance with rotational sensors (equations, equalities) • Gears, gear ratios and speed (ratios and proportions) • Light sensors and threshold (inequalities) • Wheel circumference, radius and diameter (geometric relationships)
CCSS.Math.Content.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. CCSS.Math.Content.HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions*. CCSS.Math.Content.HSA-CED.A.3 Represent constraints by equations or inequalities, and by	Robotics lessons that involve *ALGEBRA* include the following: • Switch blocks (inequalities) • Programming sensors and thresholds (inequalities) • Measuring turns (equalities, solving equations) • Gears and speed (ratios, direct and indirect proportionality

systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods*. CCSS.Math.Content.HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R*. CCSS.Math.Content.HSA-REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. CCSS.Math.Content.HSA-REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.	
CCSS.Math.Content.HSG-MG.A.1 Use geometric shapes, their measures, and their properties to describe objects. CCSS.Math.Content.HSG-MG.A.3 Apply geometric methods to solve design problems.	Robotics situations involving *GEOMETRY* include: • Wheel rotations and circumference (diameter, circumference) • Identifying locations in order to program a robot to move from point to point (connected path segments) • Interlocking gears and gear ratios (discrete combinations of radii)

Science Standards Addressed: (From the National Science Education Standards)

Systems, Order and Organization The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. A system is an organized group of related objects or components that form a whole. The goal of this standard is to think and analyze in terms of systems. Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Prediction is the use of knowledge to identify and explain observation, or changes, in advance. The use of mathematics allows for greater or lesser certainty of predictions. Order is the behavior of units of matter, objects, organisms or events in the universe – can be described mathematically. Types and levels of organization provide useful ways of thinking about the world.	Robots are excellent examples of systems, with many heterogeneous components interacting in organized, methodical ways to achieve results as a whole that they could not have achieved separately. Examples include: • Navigation systems (e.g. sensor tells the robot where it is, programmable controller tells the robot how to interpret this information, motors move in order to achieve the desired result) • Sensing systems (electrical, mechanical, and programming elements of a sensor) • Power & transmission systems (motor, axle, gear, wheel) • Manipulator systems • Lifting systems, vision systems, etc. Each system can be broken down into subsystems. Robotics technology is built upon a series of behaviors that can be measured mathematically and are understandable and predictable. There are many examples that are easy for students to manipulate and understand: • Gears and mechanical advantage • Sensors and electronic control

	• Wheel diameter and its effect on distance traveled • Rotation sensor readings and robot path planning.
Evidence, Models and Explanation Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems. Models are tentative schemes or structures that correspond to real objects, events, or classes of events that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations and computer simulations. Scientific explanations incorporate existing scientific knowledge and new evidence into logical statements. Terms like "hypothesis," "model," "law," "theory," and "paradigm" are used to describe various scientific explanations.	The investigations included in this curriculum allow students to collect evidence to investigate scientific principles. Robots physically demonstrate many scientific concepts to make them more clear and understandable. Examples include: • Electronics and basic circuitry, which can be demonstrated using touch sensors and the NXT power supply • Gear trains, which demonstrate the ability to mathematically predict mechanical advantage and speed. • Light sensors, which can detect infrared as well as visible light.
Constancy, Change and Measurement Although most things are in the process of becoming different – changing – some properties of objects and processes are characterized by constancy; the speed of light, the charge of an electron, the total mass plus energy of the universe. Energy can be transmitted and matter can be changed. Nevertheless, when measured, the sum of energy and matter in the system, and, by extension, the universe, remains the same. Mathematics is essential for accurately measuring change. Different systems of measurement are used for different purposes. Scale includes understanding that different characteristics, properties, or relationships with a system might change as its dimensions are increased or decreased. Rate involves comparing one measured quantity with another measured quantity, for example, 60 meters per second.	Robots rely on the use of many innate constants in their basic operation. Ultrasonic sensors, for instance, calculate distance based around an assumed value for the speed of sound. In calculating the distance a robot travels per spin of its motor, fundamental mathematical relationships govern the elements of change and constancy between the different factors involved. For example, the ratio between the diameter and circumference of the wheel is constant ($C=\pi d$). On the other hand, a robot doesn't always need to use the same wheels – they can change – yet, no matter what the size of the wheel, the distance traveled per turn of the wheel remains proportional. Measurement is fundamental to all aspects of robotics, from matching dimensions of parts to ensure that they can connect properly, to measuring how far your robot went, to measuring how well a prediction matched a result.
Evolution and Equilibrium Evolution is a series of changes, sometimes gradual and sporadic, that accounts for the present form and function of objects, natural systems and designed systems. The general idea of evolution is that the present arises from materials and forms of the past. Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions. For example, opposite forces are of the same magnitude, or off-setting changes occur at equal rates.	As they build and modify their robot designs, students can trace the evolution of their creation as they adapt it in different ways that allow it to complete different tasks, building upon lessons learned from their previous designs. Equilibrium appears in many different forms as a design factor that students will encounter in designing their robots. For example, a robot's top speed is an equilibrium point between the physical force of friction and the force generated by the motor.
Form and Function	When designing robots, form always follows function.

Form and function are complementary aspects of objects, organisms, and systems in the natural and designed world.	Whether the design decision involves using large versus small wheels, making the motor power high versus low, or selecting the sensing device the robot will use, all decisions are based on what the robot is expected to do: its function. All of these decisions will affect the final form (shape) of the robot.
Science as Inquiry – Content Standard "A" Students will develop: • Abilities necessary to do scientific inquiry • Understanding about scientific inquiry Students will be engaged in activities that: • Begin with a question • Allow them to perform an investigation • Gather evidence • Formulate an answer to the original question • Communicate the investigative process and results	Some investigations focus on specific portions of the inquiry process, such as evidence-gathering or hypothesis evaluation. Others begin with a question and seek an answer using general inquiry processes. Explanation and evaluation are primary abilities applied in answering questions, not simply calculations or summarization.
Physical Science – Content Standard "B" Students will understand: • Properties and changes of properties in matter • Motions and forces • Transfer of energy Students will be able to give qualitative and quantitative descriptions of moving objects and describe the forces acting on the objects. Understanding of energy will include light, heat, sound, electricity, magnetism, and the motion of objects.	Examples: • Mechanical advantage (gears) • Basic circuitry (sensor operation) • Digital and analog electronics (sensors) • Light (lamp, light sensor) • Sound (ultrasonic, sound sensors) • Speed (motors) • Friction (robot movement) Quantitative measurement is required in all activities.
Science and Technology – Content Standard "E" Students will develop: • Abilities in technological design • Understandings about science and technology	Every investigation students conduct with the robot is motivated by the need to advance the performance of the robot in order to meet performance criteria, connecting the science with technology.

Technology Standards Addressed (From the International Technology Education Association Standards)

The Nature of Technology 1. Students will develop an understanding of the characteristics and scope of technology. 2. Students will develop an understanding of the core concepts of technology. 3. Students will develop and understanding of the relationships among technologies and the connections between technology and other fields of study.	All robotics activities provide excellent hands-on exposure to technology in use and development. • "Connect" activities feature linkages to real-world robots that allow students to connect their designs to real-world needs and solutions • Successful robot operation revolves around the application of systems concepts to make sensors, actuators, and other components work together • Design processes take into account goals, resources, and trade-off factors to achieve optimal results • Technology exists in proper context alongside applications in science, math, and engineering • Several different technologies (e.g.

	desktop computer, USB/Bluetooth peripheral interface, mobile robotics controller, electromechanical sensors and actuators) are routinely used together in the operation of the NXT.
Technology and Society 6. Students will develop an understanding of the role of society in the development and use of technology.	Activities are linked to real world robots that use similar technologies to accomplish tasks that fulfill a social and/or economic need in the real world. Example activities: • Follow the Guidelines (robot follows a line on the table; linked to AMTS real world robot, which follows a pattern on a warehouse floor to transport materials autonomously) • Hello! My Name Is… (students use sound and graphical elements to make the robot communicate with people) • Full Stop (emergency stop functionality for a runaway mobile robot)
Design 8. Students will develop an understanding of the attributes of design 9. Students will develop and understanding of engineering design 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem-solving.	Students will develop a functional robotic system in many activities, including: • Hello! My Name Is…(students design a robot to convey an emotion, then test their program with real users to see if they can correctly interpret the robot's actions) • Follow the Guidelines and Faster Line Tracking (students first build a functional line-following robot, then improve its performance by modifying the design) • Housekeeping Challenge -Students will develop their own robotic solutions to a board-based challenge.
Abilities for a Technological World 11. Students will develop the ability to apply the design process 12. Students will develop the ability to use and maintain technological products and systems.	Students will apply design processes while working with and developing the robot. Here are some basic examples: • Full Speed Ahead (students learn the basics of making the robot move) • Obstacle Detection (students add a touch sensor and an ultrasonic rangefinder to help the robot avoid collisions) • Get in Gear (students adapt the robot's drive mechanism to make it faster or slower, weaker or stronger) In the course of working with the robot, students will be responsible for the maintenance of their robots both electrically and mechanically.
The Designed World 16. Students will develop an understanding of and be able to select and use energy and power technologies 17. Students will develop an understanding of and be able to select and use information and communications technologies. 18. Students will develop an understanding of and be	The NXT robot is an example of many technologies working together as a coordinated system. • Power sources • Vehicle systems • Manufacturing and prototyping • Structural soundness and stability concepts are integral to the design of the robot's physical form.

able to select and use transportation technologies. 19. Students will develop an understanding of and be able to select and use manufacturing technologies.	• Communication

Grading Practices:

	Communication	Problem-Solving	Programming	Application
Percentage	25%	25%	25%	25%

Individual assessments will gauge communication, application, programming and problem solving of the individual concept, skill or challenge. Each individual assessment will be divided into these categories as applicable and each competency will comprise 25% of a student's grade.

General Timeline/Scope and Sequence:

The students will:

- Explore the key concepts of logic and programming
- Analyze tasks and problems
- Design and implement functional robots with specific purposes
- Reflect on successful and unsuccessful designs
- Learn the names and functions of most of the building elements in the robotics base set
- Learn how to construct robots using essentially building elements.
- Build various robots from simpler to complex using building construction instructions
- Program the above robots using the NXT-G programming language
- Incorporate the use of the computer, applicable software, and Internet in their study of the uses and history of robotics.

Quarter One	Quarter Two
History of Robotics, Building, Programming, Movement, Sensors Basic behaviors and programming Basic Sensor behavior and programming	Advanced Programming, Decision Making, Wheels and speed, gears and proportions Comprehensive programming challenges