SENDING CODE WITH CODE

Use lights and sounds to transmit encoded information across distances.

LEARNING OBJECTIVES:

Student will be able to…

- Observe and investigate how light and sound waves transfer energy from place to place.
- Use patterns to encode information to transmit a message across a room.
- Develop a robotic structure or platform that follows a program to send light and sound signals across distances.

Grades: 3-5
Time: 1-2 class periods
Materials:

- KOOV Robotics and Coding Kit and the KOOV app on an appropriate device
- Paper, colored pencils, markers
- Sight and Sound Lab Worksheet

This lesson integrates concepts and skills from Science, Math, Engineering, and Computer Science and aligns to the following National standards:

Next Generation Science Standards

Grade 4:

- **4-PS4-3** Generate and compare multiple solutions that use patterns to transfer information
- **4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Grades 3-5: Engineering Design

- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Common Core State Standards: Mathematics

Mathematical Practices:

- **MP6** Attend to precision.
- **MP7** Look for and make use of structure.

CSTA K-12 Computer Science Standards: Grades 3-5

- **1B-CS-02** Model how computer hardware and software work together as a system to accomplish tasks.
- **1B-AP-08** Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
- **1B-AP-10** Create programs that include sequences, events, loops, and conditionals.
- **1B-AP-12** Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
- **1B-AP-15** Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

Lesson Overview:

- This lesson integrates an exploration of light and sound waves with the practice of using patterns to send information over distances.

Pre-Lesson Preparation:

- The first stage of this activity requires a shorter distance, such as a classroom, and a control of the ambient noise level, so it is best to be in a classroom in which you can control the noise level.
- Secondly, this lesson will need a much larger space so that students can experiment sending the message across a longer distance. Ideas include a gymnasium, auditorium, or even outside, if weather and equipment permit.

Connected KOOV Robot Recipes and Helpful Tips for Educators:

These robot recipes and related code should be used as reference in this lesson.

- **Rhythmic Drum** – Brushing Up on Your Coding Skills Mission 6
- **Koala** – Learning Mechanisms of Robots Mission 1

KOOV components needed include the Buzzer and the LED lights. Students should program the Core Buttons to send the message.

You may want to develop a code as a class, and allow advanced students enjoy the challenge of developing a new code. Another option to help students is to create a code for whole words, instead of letters..

<table>
<tr>
<td>INTRO – LET'S MAKE A SECRET CODE… TWICE</td>
<td>Use an online tool to produce a message in Morse code, and play it for the class.

Pose these questions to the class:
• What sense are we using to get this message? (Hearing)
• What other ways do we take in information? (Sight)
• If Morse Code is using hearing by listening to short and long sounds, how could we use a code that we see with our eyes?

Show class a visual-based messaging system like the semaphore system and the International Code of Signals.

Students will create "secret" codes with a partner and send messages with light and sound waves across different distances.

Students will use 4 colors (the white, red, blue, and green LEDs) to develop a sight-based code or pattern to use to send a secret message to a partner.

Next, students will need to develop a similar code to send a message with sounds to make patterns*. Tell students that they can work more on the sound-based code when they start working on with the Buzzer.

Student should record their codes on paper using colored pencils or markers.

*Some students may choose to use different tones for their codes, and some may use a beat-based code like a Morse code. It is good to have both examples for this investigation, so encourage students to experiment.</td>
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PART 2 – BUILD AND PROGRAM YOUR SECRET MESSAGE MACHINE	Place students in small groups. Pose the following questions:. Explain that this project has three criteria or objectives to meet: • It must use all 4 LED lights and the Buzzer. • Programmed to send a total of 4 unique messages. • Each message should be its own **function** in the program, and these functions should be mapped to each one of the Core Buttons. Each partner is responsible for programming two messages: One in sound, and one with lights. Partners will use the same code, but should not share the messages' programs. Students should also spend time debugging the program and testing their messaging platform to ensure that it works as intended.
PART 3 – SEND AND RECEIVE YOUR SECRET MESSAGES	Have student partners set up on opposite sides of the classroom; one with the signaling device and one with paper and markers/colored pencils. Partner 1 will transmit the two messages to Partner 2. Partner 2 will record the code they observe/hear. Partners will switch and repeat the process. Students should not de-code the messages at this point, and you should collect the recorded codes so students can not refer to them during the next round of messaging. Next, students will move to another space to transmit the same messages across a longer distance. **You may wish to add another variable to the experiment by altering the ambient sound while the messages are being sent. Have students send the sound message while the room is both loud and quiet.*
PART 4 – DEBRIEF AND WRAP-UP	Have students decode the messages they recorded, and then discuss the following questions with their partner. • Over the shorter distance, which was easier to do – recording the light-based code's message or recording the sound-based code? What made it easier? • When you sent the message over a longer distance, which method was easiest to record? Why do you think that? • Would sending the light-code message at night would help or make it more difficult to record the message? • If you had to make another secret code, would you use the same code? • Do you think that sound or light travels better across long distances? Lastly, have students answer the reflection questions on the Sound and Light Lab Worksheet. As students finish, have teams clean up and break down their signaling robots and put away all materials.

Sound and Sight Lab Worksheet

Name: ___________________________

Partner:__________________________

Work with your partner to create **TWO** secret codes using lights and sounds.

- **Light-based Code**: Use the four colors of the LED lights to make up a secret code.
- **Sound-based Code**: Use the sounds on the Buzzer to create a secret code.

On a separate sheet of paper, write out one secret message using the Light code, and write a different secret message in the Sound code.

Use a 3 second pause between words to be the space between the words in your message.

Send and Receive Your Messages

- You will record the messages you receive on a sheet of drawing paper.
- After all messages are sent, decode the messages using the codes you made.

The message sent by light:

The message sent by sound:

Reflection Questions

How successfully were you able to send messages back and forth?

Which message and which distance was the hardest for you to receive and record?

Which code was the most difficult to create? Why did you find it more difficult than the other code?

If you had to send a message across a city, would you choose a sound-based code or a light-based code? Why?

How do you think the Internet sends messages?

PICASSOBOT

Program a robotic artist to draw just like a human.

LEARNING OBJECTIVES:

Student will be able to…

- Use geometric shapes to create an original artwork.
- Modify and build a robot that holds a marker and draws out a copy of the original artwork.
- Measure the side lengths, perimeters, and angles of the geometric shapes used in the original artwork.

Grades: 3-5
Time: 1-2 class periods
Materials:

- KOOV Robotics and Coding kit with the KOOV app on an appropriate device
- Drawing paper, markers
- Rulers and protractors

This lesson integrates concepts and skills from Math, Engineering, and Computer Science and aligns to the following National standards:

Common Core State Standards: Mathematics

Grade 3:

- **3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units.
- **3.G.A.1** Understand that shapes in different categories may share attributes, and that the shared attributes can define a larger category. Recognize rhombuses, rectangles, and squares as examples of quadrilaterals, and draw examples of quadrilaterals that do not belong to any of these subcategories.
- **3.MD.D.8** Solve real world and mathematical problems involving perimeters of polygons, including finding the perimeter given the side lengths, finding an unknown side length, and exhibiting rectangles with the same perimeter and different areas or with the same area and different perimeters.

Grade 4:

- **4.MD.C.5** Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement.
- **4.MD.C.6** Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.

Mathematical Practices:

- **MP1** Make sense of problems and persevere in solving them; **MP4** Model with mathematics; **MP5** Use appropriate tools strategically; **MP6** Attend to precision; **MP7** Look for and make use of structure.

Next Generation Science Standards

Grades 3-5: Engineering Design

- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

CSTA K-12 Computer Science Standard: Grades 3-5

- **1B-CS-02** Model how computer hardware and software work together as a system to accomplish tasks.
- **1B-AP-08** Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
- **1B-AP-10** Create programs that include sequences, events, loops, and conditionals.
- **1B-AP-12** Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
- **1B-AP-15** Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

Lesson Overview:

- Students modify an existing design to create a robot that draws shapes and can follow a program to recreate drawings made by students.

Pre-Lesson Preparation:

- It may be a good idea to show students examples of geometric art (or Cubism to relate to Picasso) at the beginning of this lesson.
- You may wish to have a pre-made Picassobot prototype available for demonstration purposes to help give students a more concrete example of today's task. You can ask advanced/older students to build this.

Connected KOOV Robot Recipes and Helpful Tips for Educators:

These robot recipes and related code should be used as reference in this lesson.

- **Alpaca** – Learning Mechanisms of Robots Mission 4
- **Giraffe** – Learning Mechanisms of Robots Mission 5

You may decide to use only the Alpaca design as it allows for better turning of the wheels to make acute and obtuse angles, but it may be better to allow students to experiment with both designs in order to compare the designs.

Intro to Lesson – Let's Draw	Students use pattern blocks or shape templates to create an original artwork with each shape touching another at least one point or side. As students finish up, they will turn to a partner and describe how they drew their picture, without showing the picture. The partner should try drawing the picture as it is being described.. Today's challenge is to write an **algorithm**, or a step-by-step set of directions, to draw your exact picture – using a robot artist.
Part 1 – Modify a Robot and Teach it to Draw	In teams of two, students decide on one partner's artwork to use for this activity. Early finishers and advanced students can create programs for both artworks. The robot will need to: • Hold a marker in an upright position that stays in constant contact with the paper. • Move in all four directions and make turns. Students will need to measure side lengths and interior angles of shapes in their drawing. They will need to use trial and error to program the robots to move a specific distance. You can simplify this by compiling a class list of speeds and times for the DC motors to move a set distance. *The biggest challenge will be for students to learn how to make the robot turn in any angle other than 90 degrees. You can simplify the activity to only include certain benchmark angles, e.g. 90, 45, 270. *If teaching a 3rd grade class, you can give the students a list of angles to use to make certain shapes.*

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PART 2 – PICASSOBOT DRAWS LIKE A HUMAN	Students will need plenty of time to develop and refine the program. Testing is an important focus of today's lesson, and students are encouraged to try out different solutions to create a near-exact reproduction. Give students the option to redraw the original drawing now that they have some experience coding the robot to draw. • Are hexagons and triangles hard to draw? • What about a trapezoid or a rhombus? • What shapes are the easiest to program the Picassobot to draw? • Can you make a better work of art using different shapes? **Expect students to struggle**, and it is important for students to be challenged, but students should experience success in programming to draw simple shapes. Creating a new artwork and a new program gives students the opportunity to go "back to the drawing board" – an important aspect of engineering. Have teams present their Picassobot in a live demonstration. Teams should display and explain their program. Videos of the demonstrations are encouraged (see below).
PART 3 – DEBRIEF AND WRAP-UP	Have two teams meet together and discuss the following: • What was the easiest part of this project? What were the hardest parts? • If you had to this activity to do over, what would you do differently? • Which shapes were the easiest to program the robot to draw? • Which shapes were the hardest? • Do you think robots will take over the art world? Bring the class back together and go over the discussion questions, asking for volunteers to recount what they discussed in the smaller group. Have student volunteers create a wall display for the robot-produced drawings side-by-side with the original human-produced drawings. Another option is to have students make videos of the actual process of the robot drawing the same image as the students. These can be posted on a class or school website. These videos can also be added to the **KOOV app's Free Production gallery** to show off their Picassobots.

Programming Art Worksheet

Name: ______________________________
Teacher:______________________________

Writing an algorithm

Just like you programmed a Picassobot, you will program a human to draw by writing an algorithm, which is a set of step-by-step instructions to be followed to complete a task.

First, use this space to draw a picture that uses simple lines, like a cartoon.

Next, write a program using **pseudocode** (a way to write a computer program using everyday language without using all the technical terms and symbols) to teach a friend how to make the same drawing. Estimate your measurements. Use extra paper if needed.

Have a friend try out your algorithm. Cover up the picture you drew. No peeking.

- Was your friend able to draw the same picture?
- Where did your friend have the most trouble following your code?

Write in any corrections or fixes to your pseudocode, so your friend can draw your picture more accurately. Use a <u>colored pencil</u> to write in your fixes. Turn in your work.

MAD MARSHMALLOWS

Build a robotic catapult to send projectiles flying as far as possible.

LEARNING OBJECTIVES:

Student will be able to…

- Observe how speed and gravity affects the motion of projectiles.
- Develop a robotic catapult-like device to throw objects as far as possible.
- Collect and interpret data to predict the motion of thrown objects.

Grades: 3-5
Time: 1-2 class periods
Materials:

- KOOV Robotics and Coding kit with the KOOV app on an appropriate device
- Different sizes of marshmallows (or similar item in two sizes)
- Meter sticks or measuring tape
- Masking tape to mark distances on floor
- Various shapes, sizes, and masses of projectiles for further testing and competition
- Projectile Motion Lab Worksheet

This lesson integrates concepts and skills from Science, Math, Engineering, and Computer Science and aligns to the following National standards:

Next Generation Science Standards

Grade 3:

- **3-PS2-2** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Grade 4:

- **4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object.

Grade 5:

- **5-PS2-1** Support an argument that the gravitational force exerted by Earth on objects is directed down.

Grades 3-5: Engineering Design

- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Common Core State Standards: Mathematics

Grade 3:

- **3.MD.A.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).
- **3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories.
- **3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch.

Mathematical Practices:

- **MP4** Model with mathematics; **MP5** Use appropriate tools strategically; **MP6** Attend to precision; **MP7** Look for and make use of structure.

CSTA K-12 Computer Science Standards: Grades 3-5

- **1B-CS-02** Model how computer hardware and software work together as a system to accomplish tasks.
- **1B-DA-06** Organize and present collected data visually to highlight relationships and support a claim.
- **1B-AP-08** Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
- **1B-AP-10** Create programs that include sequences, events, loops, and conditionals.
- **1B-AP-12** Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
- **1B-AP-15** Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

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Lesson Overview:

- Much like a certain famous game, students will experiment with projectile motion, launching objects into the air with their very own robotic catapult.
- You may choose to draw more focus to observing and predicting **motion** for grade 3, **speed's affect on motion** for grade 4, and the effects of **gravity** for grade 5.

Pre-Lesson Preparation:

- The Connected KOOV Robot, the **Dolphin Kicker**, is an important starting point for this project and should be completed by students at a prerequisite for this lesson.
- This lesson requires leared floorspace. You may reuse the lanes created in the Bumper-Bots lesson, with wider lanes.

Connected KOOV Robot Recipe:

This robot recipe and its related code should be used as reference in this lesson.

- **Dolphin Kicker** – Brushing Up on Your Coding Skills Mission 1

INTRO TO LESSON – KICK OR CATAPULT?	In teams, students explore the kick function of the **Dolphin Kicker** using the guidance of the following questions: • If you change the angle of the servo motor, how does it affect the kick? • What if you change the speed? • How could we get the ball to go up in the air higher? As a class discuss the guiding questions. Use examples of catapults to show greater range of distance and height when compared to kickers. Challenge students to take the Dolphin Kicker and change the robot into a catapult.
PART 1 – MODIFY AN EXISTING ROBOT AND PROGRAM	The catapult design will need to have: • A servo motor to power and set the speeds and angular rotation of the throwing arm. • A sturdy, balanced construction to keep catapult upright as it throws. • A starting mechanism like the Core Buttons. Using marshmallows (1 of each size), teams will test their design and program. Encourage experimenting with different servo motor speeds and angles. Teams will program the different speeds for the servo motor as **functions**. Students will test and debug programs.

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Part 2 – Projectile Lab	Student teams move to the launch area to run their programs and collect data. For each launch, students record: • Mass of projectile • Distance of the projectile thrown • Speed and angle of rotary movement of servo motor Students will collect data for both sizes of projectiles.
Part 3 – Debrief and Share Findings	Teams display their data with a **bar graph,** drawn by hand or using a spreadsheet program or other online tool. Pose the following discussion questions: • What did you notice about the data you collected? • Can you draw any conclusion from your investigation? • How does the mass of a marshmallow affect the distance the marshmallow is thrown? • Does the speed of the throw affect the distance? • How does the size of the swing, or the rotary angle of the servo motor, affect the distance? • What keeps the projectile from going even farther? (*Gravity*) Student will complete the worksheet questions, at any time, but after the competition is best.
Part 4 – Catapult Challenge	Teams may change the design of their catapult before the challenge. Introduce new objects as projectiles that include various shapes, sizes and masses. Have each team practice launching the new projectiles and adjust the program for their catapult as needed. Options for Challenges: • Farthest projectile thrown (same projectile) • Farthest projectile thrown overall (any projectile) • Hitting targets with projectiles • Going over a “wall” and other obstacles • Heaviest projectile thrown the longest distance • Most artistically pleasing or interesting catapult design • Let students create their own challenge As students finish, have teams clean up and break down their robots and put away all materials.

PROJECTILE MOTION LAB WORKSHEET

Name: ___________________________________
Teacher:_________________________________

My Team Members:

Find the mass in grams of the **smaller** projectile:_____________________________
(This goes in the Mass of Object column.)

Mass of Object (g) (stays the same in this table)	Servo Motor Angle (stays the same)	Speed of Throw (the variable that changes)	Distance of Travel (to the nearest ½ cm)

Find the mass in grams of the **larger** projectile:_______________________________
(This goes in the Mass of Object column.)

Mass of Object (g) (stays the same in this table)	Servo Motor Angle (stays the same)	Speed of Throw (the variable that changes)	Distance of Travel (to the nearest ½ cm)

Display Your Data

Take the data and make a **bar graph**. The graph should show the differences in how far the different projectiles go at different speeds.

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Projectile Motion Lab Worksheet Questions

Name: ______________________________

1. What do you notice about your data?

2. How does the mass of a marshmallow affect the distance that marshmallow is thrown?

3. How does the speed of the throw affect the distance?

4. How does the size of the swing, or the rotational angle of the servo motor, affect the distance?

5. What keeps the projectile from going even farther?

6. What do you think makes more difference – the angle of the throw or the speed of the throw?

7. You have to send a baseball over a castle wall. Describe the catapult you would build and how you would program it? What type of speed would you use? What kind of throwing angle would you use?

8. Now you have to send a bowling ball over the same wall – how would you change your catapult and program?

9. How do you think the mass of your catapult affects on how far it can throw things?

Bumper-Bots

Use robots to investigate how objects move after a collision.

Learning Objectives:

Student will be able to…

- Observe and make predictions about how objects move after a collision.
- Modify and build a robot that runs autonomously and has a "bumper."
- Measure mass and distance, collect the data, and create a visual display.

Grades: 3-5
Time: 1-2 class periods
Materials:

- KOOV Robotics and Coding kit with the KOOV app on an appropriate device
- Cardboard for creating collision testing lanes
- Meter sticks or measuring tape
- A scale to measure mass
- Various sizes and masses of balls (tennis, table tennis, golf, basketball, etc.)
- Various irregularly shaped objects to push across a floor
- Collision Lab Worksheet

This lesson integrates concepts and skills from Science, Math, Engineering, and Computer Science and aligns to the following National standards:

Next Generation Science Standards

Grade 3:

- **3-PS2-2** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Grade 4:

- **4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- **4-PS3-3** Ask questions and predict outcomes about the changes in energy that occur when objects collide.

Grades 3-5: Engineering Design

- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Common Core State Standards: Mathematics

Grade 3:

- **3.MD.A.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).
- **3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories.
- **3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch.

Mathematical Practices:

- **MP4** Model with mathematics; **MP5** Use appropriate tools strategically; **MP6** Attend to precision; **MP7** Look for and make use of structure.

CSTA K-12 Computer Science Standards: Grades 3-5

- **1B-CS-02** Model how computer hardware and software work together as a system to accomplish tasks.
- **1B-DA-06** Organize and present collected data visually to highlight relationships and support a claim **1B-AP-10** Create programs that include sequences, events, loops, and conditionals.
- **1B-AP-12** Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
- **1B-AP-15** Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

Lesson Overview:

- Students will modify existing robot designs and build vehicles that can run at set speeds to test how speed affects collisions.
- Students will modify their own design to make it significantly heavier or lighter to see how mass affects collisions.

Pre-Lesson Preparation:

- Use cardboard or other sturdy, flat material to create narrow “lanes” in which teams can operate to run tests and avoid unintended collisions.
- Each lane should have a marker (a sticker or masking tape X) so that students can set up the object on the same spot during the collision tests.

Connected KOOV Robot Recipes and Helpful Tips for Educators:

These robot recipes and related code should be used as reference in this lesson.

- **Tractor** – My First Robot Coding Course Mission 5
- **Race Car** – Learning Mechanisms of Robots Mission 2

Students program the DC motor to run at a different speeds during the testing. Have them create functions and map these to the Core Buttons.

The Bumper-Bot needs a command to stop its motion. The IR Photoreflector can be set to shut off the motor when the distance between the sensor and the object to be bumped is 0.

Intro to Lesson – What Does a Bump Do?	Spread out four small identical balls in a row in one of the collision lanes. Have 2 volunteers use tennis balls to roll it toward one of the pre-set balls. Pose these questions: • Did the second roller roll the ball faster or slower than the first roller? • How do we know it was rolled faster/slower? • What happened to the ball that got bumped? • Did the speed of the rolled ball affect the collision? Two more volunteers will use a smaller, lighter ball and then a heavy, larger-sized ball. • What happened to the ball when it was bumped by a smaller ball? • What happened to the ball when it was bumped by a larger ball? Explain that they will be conducting experiments with collisions.
Part 1 – Build Your Bumper-Bot	The bumper-bots will need to: • Roll at a specific speed toward an object. • Have a bumper to protect the bot as it collides with objects. • Use the DC Motor to provide power to the wheels and to set different speeds. • Use the IR Photoreflector to stop the bumper-bot after the collision. • Use the Core Buttons to start the bumper-bots program. Student should use the **Tractor** and the **Race Car** as a starting point for their designs and programs. Students should call **functions** mapped to Core Buttons to make the bot travel at 4 different speeds.

PART 2 – COLLISION LAB	Students should take turns handling the robot, recording data, and measuring the distance the object moves after the collision. Students will record data in the **Collision Lab Worksheet**. Students will also record the **mass** of the bumper-bot, the mass of the object that is bumped, the **speed** of the bumper-bot, and the **distance** of the object that moves after the collision. After collecting data for the first set of trials, teams will change the bumper-bot to be either heavier or lighter. Teams return to the testing lanes, and record data for a new set of collisions. Students will add this data to the data sheet, as they run the bumper-bot at the same speeds as in the first set of trials.
PART 3 – DEBRIEF AND INTERPRET YOUR RESULTS	Once teams finish collecting data, they will **draw a bar graph** by hand or use a spreadsheet program or other online tool to create a bar graph. Pose the following discussion questions: • What did you notice about the data you collected? • Can you draw any conclusion from your investigation? • How does the mass of a bumper-bot affect the distance the object moves after the collision? • Does the speed of the bumper-bot affect the distance of the object's path after the collision?
PART 4 – BATTLE OF THE BUMPER-BOTS	Teams will build modify the bumper-bot using the students' new understanding of energy transfer in a collision. Introduce new objects as bean bags, erasers, blocks, toys, and other small irregularly shaped objects. These objects can be used in the Battle of the Bumper-Bots. Students will try to build the biggest bumper-bot and run it at the fastest speed, but some may try other designs. Encourage all designs. Run the competition in a way that works for your students. They could all line up at once, or you can have a round robin or categories. Options include: • Longest distance of a specific object bumped by bot • Longest distance of any object bumped • Straightest collision path • Best design artistically or creatively • Heaviest object bumped for a certain distance • A bumper-bot tug of war, but with pushing • Let students come up with contests Have students complete last section of the lab worksheet. Collect these for assessment. As students finish, have teams clean up and break down their Bumper-Bots and put away all materials.

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COLLISION LAB WORKSHEET

Name: ___________________________________
Teacher:_________________________________

My Team Members:

Find the mass in grams of the **bumper-bot**:________________________________
Find the mass in grams of the **object being bumped:**________________________

Mass of Bumper-Bot (g)	Speed of Bumper-Bot	Mass of Object (g)	Distance of Travel (to the nearest ¼ inch)

Find the mass of the lighter or heavier **bumper-bot**:________________________
Find the mass in grams of the **object being bumped:**________________________

Mass of Bumper-Bot (g)	Speed of Bumper-Bot	Mass of Object (g)	Distance of Travel (to the nearest ¼ inch)

Display Your Data

Take the data and make a **bar graph**. The graph should show the differences in how far the different projectiles go at different speeds.

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Collision Lab Worksheet Questions

Name: ________________________________

1. What do you notice about your data?

2. How does the mass of your Bumper-Bot affect the distance the bumped object moves?

3. How does the speed of the Bumper-Bot affect the distance the bumped object moves?

4. What do you think makes more difference – the speed of the Bot, the mass of the Bot, or the mass of the object being bumped? Explain why you think this.

Use this space to draw a diagram or picture to explain how objects move after a collision.

Clean Up in Aisle 5

Design a robot to clean up a given area in the most efficient way.

Learning Objectives:

Student will be able to…

- Accurately measure and determine the area of a given space.
- Design a robot that can clear a given space of all objects.
- Find the most efficient pattern of movement for a robot to clear a given space.

Grades: 3-5
Time: 1-2 class periods
Materials:

- KOOV Robotics and Coding kit with the KOOV app on an appropriate device
- Rulers, meter sticks, or measuring tape
- Drawing paper
- Several pre-made identical rectangular areas taped off
- Stopwatches or timers
- Various small objects to be pushed across the floor
- Clean Up Your Mess Worksheet

This lesson integrates concepts and skills from Math, Science, Engineering, and Computer Science and aligns to the following National standards:

Common Core State Standards: Mathematics

Grade 3:

- **3.MD.A.1** Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram.
- **3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units.
- **3.MD.C.5** Recognize area as an attribute of plane figures and understand concepts of area measurement.

Grade 4:

- **4.MD.A.3** Apply the area and perimeter formulas for rectangles in real world and mathematical problems.

Mathematical Practices:

- **MP1** Make sense of problems and persevere in solving them; **MP4** Model with mathematics; **MP5** Use appropriate tools strategically; **MP6** Attend to precision; **MP7** Look for and make use of structure.

Next Generation Science Standards

Grade 3:

- **3-PS2-1** Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Grade 4:

- **4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object.

Grades 3-5:

- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

CSTA K-12 Computer Science Standards: Grades 3-5

- **1B-CS-02** Model how computer hardware and software work together as a system to accomplish tasks.
- **1B-AP-08** Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
- **1B-AP-10** Create programs that include sequences, events, loops, and conditionals.
- **1B-AP-12** Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
- **1B-AP-15** Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

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Lesson Overview:

- Students will decide which existing design and programming to modify in order to create a robot that clears objects from a given area. You may wish to choose one design for students to use, but this lesson is meant to give students more room to make independent decisions

Pre-Lesson Preparation:

- Have a large number of small irregularly shaped objects of different weights to act as the "mess" for the robots to clean up. Also, tape off or mark out several rectangles on cleared floorspace.

Connected KOOV Robot Recipes and Helpful Tips for Educators:

These robot recipes and related code should be used as reference in this lesson.

- **Alpaca** – Learning Mechanisms of Robots Mission 4
- **Giraffe** – Learning Mechanisms of Robots Mission 5

The **Bumper-Bots lesson** is a good prerequisite for this lesson as it gives students experience in using a robot to push objects and understand how force and mass affect this motion.

Intro to Lesson – Can a Robot do Chores?	Take a quick survey to find out what chores are the least favorite among your students. Cleaning should get a big response. Explain that the challenge today is to create a robot that can help you clean up. The challenge is to clean the area in the most efficient way (fast and does a good job). Some previous designs and lessons for reference: • Alpaca – movement in all four directions • Giraffe – movement backward and forward • BumperBots – how best to use mass and speed to push objects Students will need to decide which robot design would be best for this task.
Part 1 – Design and Build a Robot to Clean Up the Mess	The robot will need: • A balanced, sturdy construction to keep its balance as it moves objects. • Enough mass and speed that it can push multiple objects. • A bumper, which can be in any shape or angled. Students will work in teams to produce the robot and program. Have them visit the test areas to take measurements. The robot's program can use **sequences**, **loops**, and **functions**. Students may need to experiment with time and speed of the DC and/or Servo motors in order to find a way to program the robot to go a certain distance.* Teams should test robots in the "clean-up" areas. Small messes can be made using small objects. *If students struggle with the exact distance programming, you may want to develop a class list of speeds and times to correlate to the testing areas' distance to travel.

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Part 2 – How Fast can a Robot Clean the Floor?	After teams get their robot successfully cleaning the given area, teams will need to find the most **efficient** way to clean the area. Students should re-examine the testing areas and find a path for the robot to take around the area in order to clear it as quickly as possible. They should use paper to draw out their ideas and solutions. These may include going row by row and turning around often, or making more circular movements. Draw student attention to the shape of a bumper and how the robot moves objects. • What directions do objects move after your robot's bumper hits them? • Could you design a bumper to help your robot clean your area better and faster? Give students more time for testing and making their code better. Students should use stopwatches or timers to find the total time it takes their robot to clean the area. The goal is to get their time down to the fastest time for the coming competition.
Part 3 – Wrap-Up and Debrief	Student teams will compete in a round robin tournament to find the best robot for cleaning up a mess. You may decide to alter this tournament format for your class needs. Sharing videos of the cleaning robots in the KOOV app's **Free Production** gallery are encouraged. Once the competition is over, lead the class in a debrief, asking these questions: • What did you notice about the robots that cleaned the fastest? • What did you notice about the robots that cleaned the best? • Did you notice anything that was similar about the robot designs and/or the programs that were the most efficient? Least efficient? • Was there one path that the robot used that seems like it's the quickest way to clean the area of a rectangle? If time permits, you can give students more time with changing their robots and/or programs and have more informal competitions or different types of challenges. Finally, have students complete the final section of the worksheet. Have teams clean up and break down their robots and put away all materials.

Clean Up Your Mess Worksheet

Name: ___________________________________
Teacher:__________________________________

My Team Members:

Which robot (or robots) is your team using as the starting point of your own design?

Why did you pick this robot? Did everyone on your team agree that this was the best choice?

Record the measurements of the area to be cleaned.

- The length is
- The width is

What is the total area of the space to be cleaned? Show your work.

Show What You Know

Use **pseudocode** (a way to write code using normal words, such as "move ten steps forward") that you think would be the fastest way to have a robot clean the floor space of a small room . Use the back of this page if you need more room.

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