Elementary Robotics Six-Session Lesson Plan

Grades 3-5

LexRobotics
Lexington Education Foundation
Lexington Public Schools

Lesson One

Introduction

<u>Objective:</u> To introduce students to fundamental engineering concepts.

<u>Lesson Overview:</u> In this lesson, students will learn about the core ideas of engineering by completing a simple challenge in small groups. Students will be introduced to basic abstracts of hardware, software, and the engineering thought process, with an emphasis on testing.

<u>Materials:</u>

12 Mindstorm EV3 kits. Set up the 12 kits around the classroom for students to sit with.

- Pre-Built Chassis (x12). 1 chassis per group. Groups of 2-3 students.
- Pre-program all chassis to move forward, then back (name “ForwardBack”)
- Container with raised wall, small cubes (for challenge)

<u>Procedure:</u>

Total Length – 1 hour

1. Introduction. 30 seconds.
    a. Give name, position, involvement
2. (Optional) Icebreakers. 5 minutes.
    a. Only do if necessary due to tight time constraints.
3. What is Robotics and Engineering? 1 minute.
    a. Ask any student in the room to try and define engineering, then give a further explanation.

“When I explain what engineering is, I like to use a little joke. A physicist, a mathematician, and an engineer are preparing a fire in a field. Suddenly, a minor spark lands on a piece of grass, creating a small fire. The mathematician pulls out a notepad and starts calculating how quickly they have to put the fire out before it spreads too far. The physicist runs inside to grab a bucket of water. The engineer simply stamps the fire out with his or her boot.

At its core, engineering is all about problem-solving in the most efficient way possible. In the joke, the mathematician’s solution is slow, the physicist’s solution is a logical response but not necessarily the best, and the engineer’s response is the simplest and fastest. The engineer saw a problem – the fire – and used his or her resources – the boot – to his or her advantage. Robotics is a subset of engineering which deals with the design, construction, operation, and application of robots to complete a variety of tasks. Whether it be to clean up a room or to save a life, robots and engineering are constantly affecting the way we live.”

4. Hardware/Software Talk. 2-3 minutes.
    a. Pull out one of the EV3 chassis and place it in clear view for all students to see. Ask students to analyze the different parts they see on the chassis before going into the talk.

"All robots or electronic gadgets have two primary components: hardware and software. Hardware is the actual construction of the object. The items you noticed on the chassis – be it a wheel, an axle, or even the brick itself – are examples of hardware and act as the body of the device. What you cannot see here is the software controlling the robot. If hardware is the body, then software is the brain. An app on a phone or a command to make a robot move are examples of software. How many of you have siblings? Ever dreamed of being able to control your sibling? That's programming.

Hardware and software are like jam and bread – they feel incomplete separately, but put them together and you have something great. Let's take this chassis, for example. Without programming, hardware is just a fancy brick. Without hardware, software is just a digital file on a computer that controls nothing.

The challenge chassis for today is pre-programmed with a basic command: move forward, then backward. However, there is a restriction of no extra programming on this challenge. So, for example, you would not be able to make a claw which can open and close as that would require a programmed motor. Consequently, it is important to understand how to create hardware to work around these limitations for today's challenge."

5. Engineering Thought Process. 3-4 minutes.
    a. Ask students what they think goes through an engineer's head when they try to solve a problem before going into the talk.

"Contrary to common belief, engineering is not about building the biggest or most complex contraption possible – it is about the exact opposite of that. Engineers are the only ones in the world whose job is to create something which requires the least amount of time, money, and effort to use. All big inventions – the car, the telephone, even the rocket ship – started out as small ideas. Take the Internet for example. The Internet originally started out with a guy who needed a way to organize all of his junk in one space. Now, that 'junk' has turned into the largest and most complex database in the world used by all. He was a carpenter who built a cabinet, only to find out he could fit the entire world inside. Yet it all started out as a simple idea – organizing a bunch of 'junk'. Those of you with messy rooms may understand how difficult that challenge can actually be.

So, when you start designing or building something, start out small and do not expect to get things right on the first attempt. You can't draw a portrait without drawing a circle first, but you won't make a perfect circle in one try. You can't write a song without learning a scale, but learning a scale takes practice. In engineering, failure is what leads to success. Each mistake leads to a better design. Thomas Edison had 1,000 unsuccessful attempts before he finally invented the lightbulb. Much of it came down to just finding the right materials to use with the limited resources he had.

Ultimately, engineering boils down to taking a simple idea and making it into a reality using limited resources in the best way possible. However, the only way to figure out whether or not one method works better than another is to test it."

6. Announcing the Challenge and Making Groups. 2-4 minutes.
    a. Display a complete field set-up for the challenge and an EV3 chassis.

Primary Challenge: Jelly Bean Buggy

Field Set-Up:

*Note: You may need a weight on the platform so that the robot does not move it when the robot bumps into the wall.

Explanation:

"Today's challenge is called the Jelly Bean Buggy challenge. Our jelly beans for today will be these small cubes *<hold out some cubes>*. Each group will be given six jelly beans, which can be placed anywhere on the robot's design *<place the cubes on top of the chassis>*. In front of the robot will be platform with a raised wall. *<remove the cubes and run the 'ForwardBack' program>* The robot has been pre-programmed to move forward, bump into the raised wall, and then move back. The challenge is to dispense four of the six jelly beans onto the platform *<drop four cubes onto the platform>*. No extra programming is allowed, so think about how you can use the initial bump *<point to the wall again>* to your advantage. There is no one solution. You may test your design at any time and as many times as you want, just let me know and we'll go to the field together. Remember, learning from mistakes is key in engineering."

Interaction with robot and field during explanation is recommended, as seen in the <>'s.

Ask the students if any of them have any questions about the challenge. If they are confused, explain the challenge a second time. Once all questions are answered, assign groups of 2-3 depending on the # of students and set each group up with a kit and a chassis. You may alternatively let them choose partners, but maintain a strict group size. If you find that some students do not work well together, you may rearrange groups in later sessions.

7. Challenge Period. Remainder of session (~45 minutes).

Each group will work independently on solving the challenge. During this time, go around from group to group and talk to them about their progress. Answer questions for students, but also ask questions of your own to guide them. Be sure to recommend testing ideas, especially if students are unsure about a design or are arguing.

Some sample questions to ask students:

- What ideas are you throwing around?
- You found one issue, what could you do to get around that?
- How could you use this piece to your advantage?

When students test their design on the field set-up, help guide them through the engineering thought process.

- Ask about the design. What's the game plan? Let them set up the cubes on the robot.
- Testing. Pay attention to what happens here so you can give advice afterwards.
- Evaluation. If the design did not work, ask them if they could see why when they tested. Then, give your own evaluation and send them back to work. If the design worked out of luck, ask how they could make their robot more consistent.

With the Jelly Bean Buggy challenge, the two main issues tend to be either that the robot design is too stiff so the cubes do not move at all, or that the robot design is too loose so the cubes fall too early.

Throughout the challenge period, give time checks to students. Especially as time gets lower, encourage students to check.

If any students finish the primary challenge early, give them a new challenge.

Secondary Challenge: Reverse Jelly Bean Buggy

Field Set-Up:

Explanation:

"In the Reverse Jelly Bean Buggy challenge, the cubes start on the platform, but away from the raised wall. The robot will still move forward, bump into the wall, and then move backward. Your challenge is to build a design which can pull the cubes back into the wall. No extra programming is allowed."

8. Final Testing & Clean-Up. Last 5 minutes.
    a. Let each group run a final test of their design. If a group is unable to finish the primary challenge, it is usually because they needed a few more minutes. Let them know this so they do not feel discouraged.
    b. After each test, have the group go back to their station and clean up by taking apart and re-organizing their mechanical attachments.
    c. Once all of the groups are done cleaning up, give a few pieces of feedback. Explain what you saw went well or went poorly today.
    d. (Optional) Present a misc. engineering item or robotics video
    e. Disperse a homework sheet to each student

Sample Homework:

Name: ____________________________ Date: _______________

In Lesson One, you received an introduction to robotics and engineering! Please complete the questions below for homework.

1. In your opinion, what is robotics and engineering?

2. What difficulties did you have in today's challenge(s)? How did you try to overcome them?

3. Each challenge is designed to have multiple solutions. List a solution that you did not use which you think could have worked.

4. Why is testing designs frequently encouraged in engineering?

5. What did you learn most from Lesson One?

Lesson Two

Hardware

Objective: To further explore robotics hardware using Lego Technic

Lesson Overview: Students will learn about hardware in an in-depth manner by comparing different Technic pieces and their functionalities. Afterwards, students will complete an all hardware challenge in small groups.

Materials:

12 Mindstorm EV3 kits. Set up the 12 kits around the classroom for students to sit with.

- Pre-Built Chassis (x12). 1 chassis per group. Groups of 2-3 students.
- Pre-program all chassis to move forward, then back (name "ForwardBack")
- Container with raised wall, small cubes, small see-saw (for challenge)

Procedure:

Total Length – 1 hour

1. Synopsis of previous lesson and of what will be learned this lesson. 1 minute.
    a. Mention what you wanted students to learn from the previous lesson.
2. Coming Up with a Design. 3 minutes.
    a. Give students a hypothetical situation. Suppose a cameraman asked you to build a robot that he can use to film a movie. What questions do you ask the cameraman or yourself? Take input from a few students, then offer a thought process yourself.

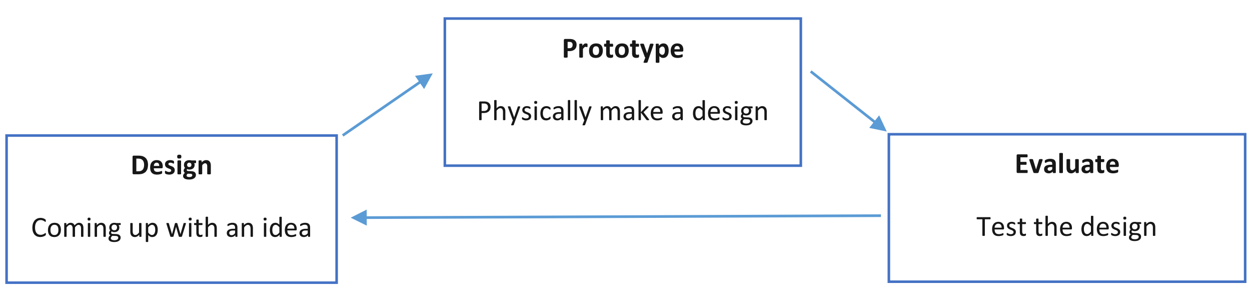
"The first question I would ask is what kinds of camera shots is he trying to capture? Does he want the camera to be able to spin, tilt, and lift? What kinds of angles is he going for? What resources do I have on hand? Suppose he wants to do all of the above at multiple different angles. Now, I can move on to designing the robot. In designing the robot, I need to be both creative and realistic and find a balance in between. For example, suppose the camera is big and I have limited resources, but still want to film from high up. I cannot make a robot that can fly and film, but I can make a robot with a lift. At this point, I ask how I can make the lift stable. A solution to this would be to make the base larger and use smaller wheels. This solution is creative, but realistic. For engineers, the balance between creativity and realism is simplicity.

Coming up with an initial design can be difficult. Often times, you may come up with too many ideas to choose from, or none at all. In making a design, consider the purpose, possibilities, and limitations. Most of all, ask questions to narrow the brainstorm process."

3. Functions of different Lego Technic pieces. 5 minutes.
    a. Have students interact with each kind of piece as you explain them. Keep examples of each with you to use during your explanation in front of the students.

Piece	Form	Function	Other
Pegs	- Standard circle peg - Long circle peg - Half-circle/half-T peg - Loose pegs vs. rigid pegs	Connecting pieces together	Some peg pieces are in nonstandard forms such as the H-shaped piece.
Beams	- Range from short to long - Straight beams - Hooked beams - Angled beams - Circle holes vs. T-holes	Structure of mechanical attachment	Keeping structural integrity in mind is important (e.x. a symmetrical design)
Axles	- Range from short to long - T-shaped	- Central rod for a rotating piece - Pivot point	Most common application is as a wheel and axle.
Gears	- Circular piece with teeth - Different sizes	Rotational energy	Gear ratios are based on the relative sizes of gears meshing together. Big to small makes speed, small to big makes torque. Two gears meshing spin in opposite directions.
Wires	Long and flexible	Connection between hardware and software	Wires can get in the way easily. Finding ways to organize wires so that they are not intrusive is key.

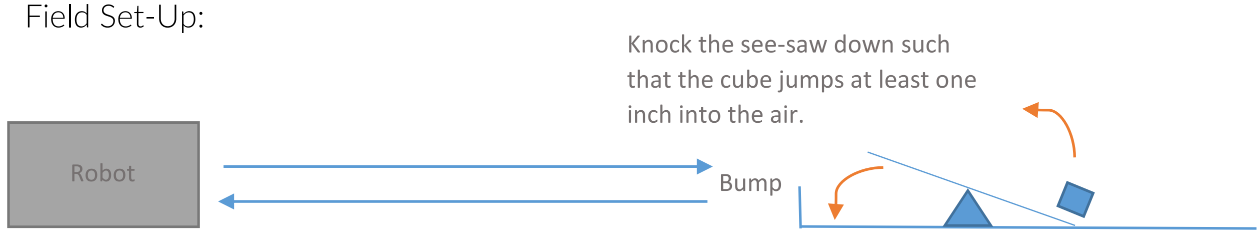
4. Iterative Process. 1-2 minute(s).
    a. The iterative process is a culmination of the broader concepts explored over the first two lessons. Discuss it as follows:



5. Announce the Challenge. 1 minute.
    a. Display a complete field set-up for the challenge and an EV3 chassis

Primary Challenge: Catapult Challenge

Field Set-Up:



*Note: You may need a weight on the platform so that the robot does not move it when the robot bumps into the wall.

Explanation:

“Today’s challenge will focus on hardware, so no extra programming is allowed. The robot has been pre-programmed to move forward, bump into the raised wall, and then move back. Inside the platform will be a see-saw. The raised end will face the robot. The lowered end will have a small cube on it. Your challenge is to build a mechanical attachment such that the robot can knock the see-saw down and make the cube jump at least one inch in the air. The raised end must touch the bottom of the platform to be a valid solution. There is no one solution. You may test your design at any time and as many times as you want, just let me know and we’ll go to the field together. Remember to keep the iterative process – design, prototype, evaluate – in mind.”

Interaction with the robot and the field set-up during the explanation is recommended.

Ask the students if any of them have any questions about the challenge. If they are confused, explain the challenge a second time. Assuming the students stay in the same groups from the previous lesson, they may begin working once all questions are answered.

6. Challenge Period. Remainder of session (~45 minutes).

Each group will work independently on solving the challenge. During this time, go around from group to group and talk to them about their progress and help as needed.

Help guide students through the iterative process. At the beginning, focus mostly on design. In the middle, focus mostly on prototyping. Throughout it all encourage testing and evaluating.

Encourage students to apply their new understanding of hardware by recommending certain pieces. The axle and loose pegs tend to be useful for this challenge as pivot points.

If a group finishes the Catapult Challenge early, you may give them the following secondary challenge:

Secondary Challenge: Basket Challenge

Field Set-Up:

Explanation:

"The robot is pre-programmed to move forward, bump into the wall, then move back. On the platform away and away from the wall will be a basket with an open loop on top. The challenge is to build a mechanical attachment which can pull the basket back to the wall without knocking it down. No extra programming allowed."

7. Final testing & Clean-Up. Last 5 minutes.
    a. Let each group run a final test of their design. If a group is unable to finish the primary challenge, it is usually because they needed a few more minutes. Let them know this so they do not feel discouraged.
    b. After each test, have the group go back to their station and clean up by taking apart and re-organizing their mechanical attachments.
    c. Once all of the groups are done cleaning up, give a few pieces of feedback. Explain what you saw went well or went poorly today.
    d. (Optional) Present a misc. engineering item or robotics video
    e. Disperse a homework sheet to each student

Sample Homework Questions:

1. What is the iterative process? Why is it important?
2. How do gear ratios work?
3. What is the significance of hardware?
4. How do you think you have improved from the previous lesson?

Lesson Three

Software

<u>Objective:</u> To further explore robotics software using Lego Mindstorm

<u>Lesson Overview:</u> Students will learn how to program an EV3 robot using the Lego Mindstorm drag-and-drop software. Through a whole class step-by-step programming lesson, students will learn the basics of working with motors, switch blocks, and sensors. From there, students will solve programming objectives in independent groups.

<u>Materials:</u>

12 Mindstorm EV3 kits. Set up the 12 kits around the classroom for students to sit with.

- Pre-Built Chassis (x12). 1 chassis per group. Groups of 2-3 students.
- 13 Laptops with the EV3 Mindstorm software (the 13th laptop is for the teacher)
- Projector
- 12 MicroUSB cables (for connecting the brick to the laptop)
- Ultrasonic Sensors (x12) or Infrared Sensors (x12)
- Touch Sensors (x12)
- Light Sensors (x12)
- Wooden blocks, Large white surface that can be written on, Sharpie (field elements)

*Note: The wooden blocks can be replaced by a variety of similar wall-like materials as their purpose is for touch and ultrasonic sensor interactions.

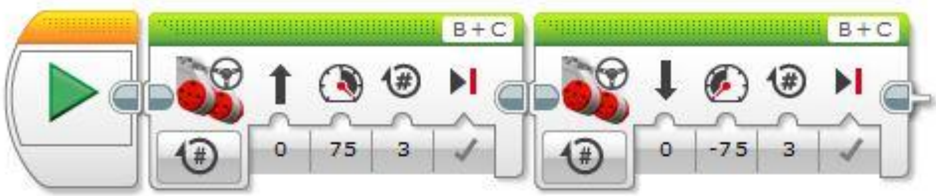
<u>Procedure:</u>

Total Length – 1 hour

1. Synopsis of previous lesson and what will be learned this lesson. 1 minute.
   a. Review the iterative process briefly
2. Whole class step-by-step programming. 15-20 minutes.
   a. The software lesson differs from the hardware lessons as it is easier to pick up hardware than software. Consequently, it is necessary to hold their hands through the basics so they have a baseline.
   b. Using the projector, the teacher will guide the following objectives step-by-step (see following two pages):

Whole Class Step-by-Step Objectives:

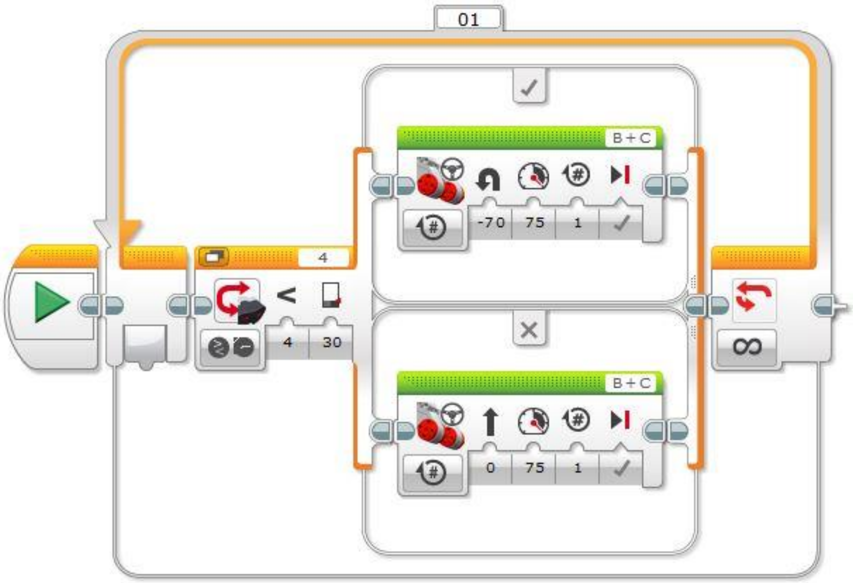
Move Forward, then Move Backward (Motor Basics)



Steering (Motor Basics)

Touch Sensor w/ Wait Function (Sensor & Function Basics)

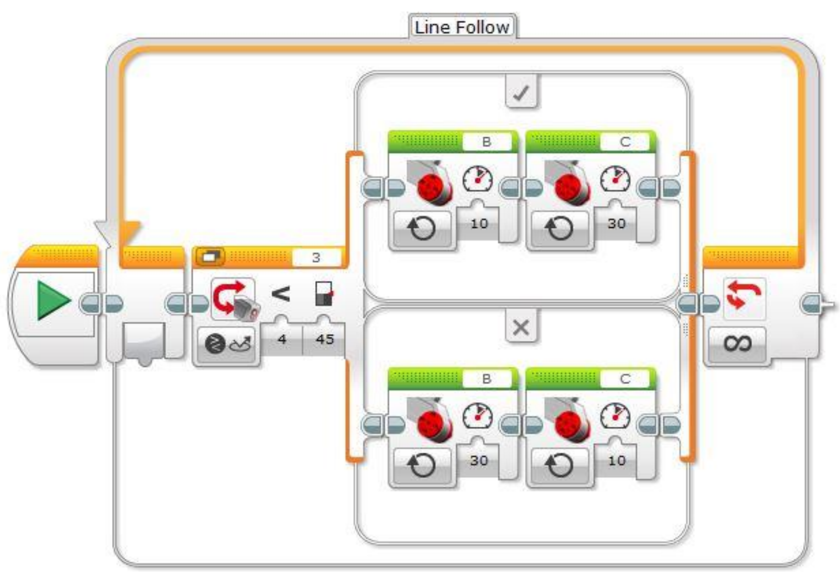
Infrared Sensor w/ Switch Loop (Loop Basics)



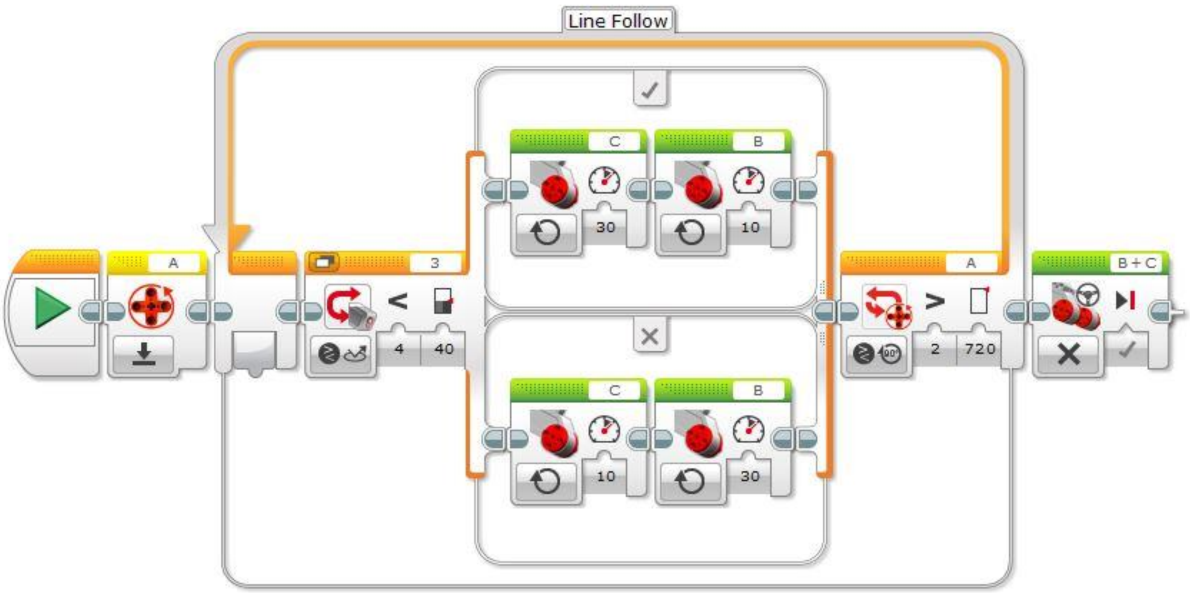
Note: The infrared sensor can be replaced with an ultrasonic sensor to the same effect of sensing distance.

3. Small Group Advanced Objective. 15-20 minutes.
    a. After going through the basics as a whole class, each small group will work on a making a line follow program on their own. Before beginning, the students will be given a Mindstorm programming quick guide as reference. During this time, float from group to group much like a challenge session.
    b. In the last five minutes, go over a sample solution as a whole as some students may not be able to figure the code out in time.

Note: A large white surface with black lines is required for the robot to be tested on. The light sensor is also required.



c. From there, go over the motor rotation block as a whole group by modifying the Line Follow program with all the students.



4. Creative Programming. Remainder of Session (~15-20 minutes).
    a. In the final third of the software session, allow students to program their robot to do anything along these three guidelines:
        i. The program must include a motor function
        ii. The program must include a sensor function
        iii. The program must include a wait, switch, and/or loop function
    b. Set up a large scale field with elements that sensors can react to such as walls for ultrasonic/touch sensors, or black lines for light sensors.
5. Final Testing & Clean-Up. Last 5 minutes.
    a. Let students test their programs for the last time and then put away the materials.
    b. Disperse a homework sheet to each student. Include this link: http://www.lego.com/en-us/mindstorms/downloads/download-software

Sample Homework Questions:

1. What is programming? Why is it important?
2. How does a switch block work in EV3 Mindstorm?
3. Explain how each of the following sensors work. Circle your favorite one!
    a. Touch   b. Light   c. Infrared   d. Motor Rotation
4. (Optional) Make your own program in EV3 Mindstorm at home.

Lesson Four

Hardware-Software Integration

<u>Objective:</u> To combine the hardware and software skills learned in previous lessons.

<u>Lesson Overview:</u> Students will learn how to bridge hardware and software together to create robots. A review of concepts learned in previous lessons will be discussed. The importance of teamwork in the engineering thought process will be emphasized as small groups must deal with both hardware and software efficiently. Afterwards, students will be given a challenge requiring both building and programming.

<u>Materials:</u>

12 Mindstorm EV3 kits. Set up the 12 kits around the classroom for students to sit with.

- Pre-Built Chassis (x12). 1 chassis per group. Groups of 2-3 students.
- 13 Laptops with the EV3 Mindstorm software (the 13th laptop is for the teacher)
- Projector
- 12 MicroUSB cables (for connecting the brick to the laptop)
- Ultrasonic Sensors (x12) or Infrared Sensors (x12)
- Touch Sensors (x12)
- Light Sensors (x12)
- Wooden blocks, small basket-like objects

*Note: The wooden blocks can be replaced by a variety of similar wall-like materials as their purpose is for touch and ultrasonic sensor interactions.

<u>Procedure:</u>

Total Length – 1 hour

1. Synopsis of previous lesson and what will be learned this lesson. 1 minute.
2. Review of hardware and software sessions. 5 minutes.
    a. Lego Technic
        i. Beams, pegs, axles, gears, wires
    b. Lego Mindstorm
        i. Pull up a sample Mindstorm program including motors, sensors, and a switch/wait/loop function up onto the projector and go over it
3. Teamwork Talk. 2-3 minutes.
    a. Reiterate the hardware-software relationship mentioned in Lesson One. Focus on helping students understand how to work together as challenges become more complexed.

"As we discussed in our first lesson, hardware and software are equally important and depend on each other. Without software, hardware is a fancy brick which does nothing. Without hardware, software is a digital file which controls nothing. In engineering, figuring out how hardware and software work together is just as important as figuring out how to work together as a team. As the challenges become more complex and involve both hardware and software, you will have to find ways to work efficiently. For example, if you focus too many hands on hardware, then the software will fall behind and vice versa. When it comes to working together as engineers, there are three primary components to consider: negotiation, delegation, communication. Negotiation most often comes out at the beginning when you try to come up with ideas. It is easy to argue here over conflicting designs. Rather than stubbornly hold on to one idea, find ways to combine designs or list out the pros and cons of each. Otherwise, you may spend all your time just arguing and doing no work. Once a design is thought up of, turn to delegation. Who is going to be working on what? Are you going to build this part, or program this aspect? Like I said earlier, you cannot make everyone fixate on one element of the robot. Typically, a company will have some people do just software, and others do just hardware. However, for learning purposes I want to see everyone work on both at some point, and I will go around to make sure this happens. When you start working, communication will become key. Everyone needs to be on the same page and be aware of hardware or software changes. Otherwise, the hardware and software will not be in sync. Similarly, you're groupmate cannot help you or if he or she can't tell what you did."

4. Announce the Challenge. 1 minute.
    a. Display a complete field set-up for the challenge and an EV3 chassis.

Primary Challenge: Pick-Up Challenge

Field Set-Up:

Explanation:

"Today's challenge will involve both hardware and software, so the robot will start with no program. It is up to you to both build and program the robot. For those of you who got to the secondary challenge in Lesson Two, it is similar to the Basket Challenge, but with programming. In front of the EV3 chassis will be a basket on a platform with a raised wall (higher than previous challenges). Your objective is to pick up the basket and lift it up and over the wall without knocking the basket down. You must use at least one sensor

Remember to begin thinking about teamwork now that there is both a hardware and software element."

Interaction with the robot and the field set-up during the explanation is recommended.

Ask the students if any of them have any questions about the challenge. If they are confused, explain the challenge a second time. Assuming the students stay in the same groups from the previous lesson, they may begin working once all questions are answered.

5. Challenge Period. Remainder of Session (~45 Minutes).

Each group will work independently on solving the challenge. During this time, go around from group to group and talk to them about their progress and help as needed.

Help students work together as a team. If an argument gets out of hand, resolve it. If a student feels like they are not contributing, get him or her a task. Keep communication clear between groupmates.

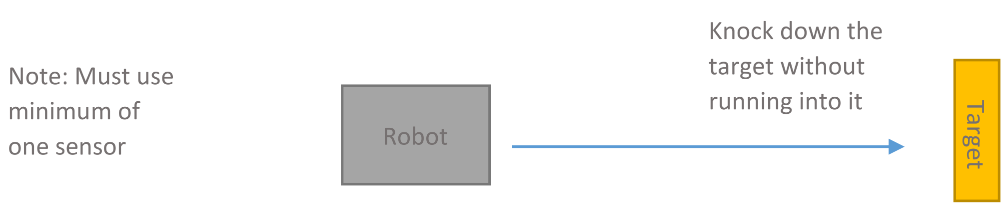
Keep track of which students are working on hardware or software and when. Periodically go around encouraging students to switch up between hardware and software.

Continue emphasizing the iterative process. Tell students to test frequently to work out issues in both hardware and software.

If a group finishes the Pick-Up challenge early, you may give them the following secondary challenge:

Secondary Challenge: Karate Kid Challenge

Field Set-Up:



Explanation:

"In front of the robot will be a block. Your objective is knock down the block without running into it. You will have to use a minimum of one sensor."

6. Final testing & Clean-Up. Last 5 minutes.
    a. Let each group run a final test of their design. If a group is unable to finish the primary challenge, it is usually because they needed a few more minutes. Let them know this so they do not feel discouraged.

b. After each test, have the group go back to their station and clean up by taking apart and re-organizing their mechanical attachments.
c. Once all of the groups are done cleaning up, give a few pieces of feedback. Explain what you saw went well or went poorly today.
d. (Optional) Present a misc. engineering item or robotics video
e. Disperse a homework sheet to each student

Sample Homework Questions:

1. What is the relationship between hardware and software? Why is it important?
2. How did doing both build and programming make things easier? Give examples.
3. How did doing both build and programming make things harder? Give examples.
4. Do you prefer hardware or software? Do you enjoy both equally? Explain.
5. Why is teamwork important in robotics and engineering?

Lesson Five

Challenge Session

Objective: To put students' abilities to the test through an advanced challenge

Lesson Overview: Students will attempt to solve a difficult challenge involving hardware, software, and all engineering thought processes previously discussed. More challenge time will be given in this lesson compared to previous lessons.

Materials:

12 Mindstorm EV3 kits. Set up the 12 kits around the classroom for students to sit with.

- Pre-Built Chassis (x12). 1 chassis per group. Groups of 2-3 students.
- 13 Laptops with the EV3 Mindstorm software (the 13th laptop is for the teacher)
- Projector
- 12 MicroUSB cables (for connecting the brick to the laptop)
- Ultrasonic Sensors (x12) or Infrared Sensors (x12)
- Touch Sensors (x12)
- Light Sensors (x12)
- Wooden blocks, Large white surface that can be written on, Sharpie (field elements)

*Note: The wooden blocks can be replaced by a variety of similar wall-like materials as their purpose is for touch and ultrasonic sensor interactions.

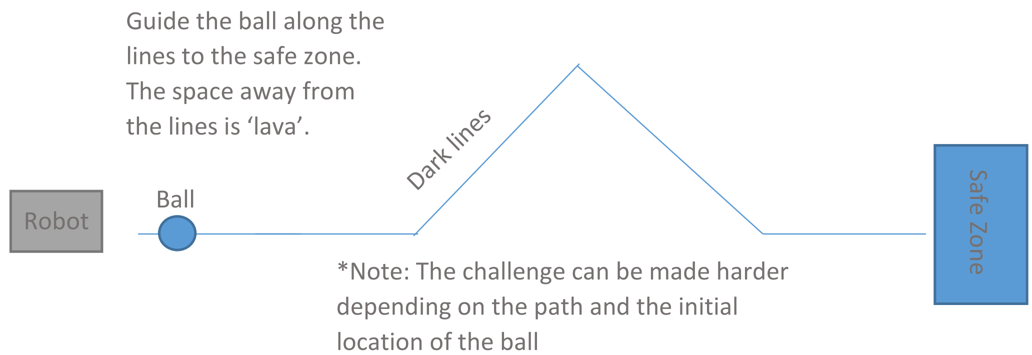
Procedure:

Total length – 1 hour

1. Synopsis of previous lessons and what will be done this lesson. 1 minute.
2. Review of hardware-software integration. 5 minutes.
    a. Bring out a sample solution to a previous hardware/software challenge and review both the build and the code
3. Review of engineering thought process. 2-3 minutes
    a. Iterative Process
    b. "Less is more"
    c. Teamwork
4. Announcing the Challenge. 1 minute.
    a. There will only be one challenge this session

Primary Challenge: Guide the Roly-Poly

Field Set-Up (Bird's-Eye View):



Explanation:

"Today, you have been given a special mission that will test your hardware and software skills. A roly-poly is trapped in a field of lava. The only way across to the safe zone is across a path of rock in the lava. Unfortunately, the environment is too hot for a human – this is a job for a robot. Your task is to build a robot which can guide the roly-poly to the safe zone without letting the robot or the ball fall into the lava. The roly-poly will begin in front of the robot. The robot will not only have to be able to navigate the path, but also be able to securely maneuver the roly-poly."

Interaction with the robot and the field set-up during the explanation is recommended.

Ask the students if any of them have any questions about the challenge. If they are confused, explain the challenge a second time. Assuming the students stay in the same groups from the previous lesson, they may begin working once all questions are answered.

5. Challenge Period. Remainder of Session (~50 minutes).

Each group will work independently on solving the challenge. During this time, go around from group to group and talk to them about their progress and help as needed.

Help students work together as a team. If an argument gets out of hand, resolve it. If a student feels like they are not contributing, get him or her a task. Keep communication clear between groupmates.

Keep track of which students are working on hardware or software and when. Periodically go around encouraging students to switch up between hardware and software.

Continue emphasizing the iterative process. Tell students to test frequently to work out issues in both hardware and software.

Since this challenge is difficult, no secondary challenge is needed. You may refer to the 'Challenge List' or switch up the path or location of the ball if a group finishes early.

6. Final Testing & Clean-Up (Last 5 minutes).
    a. Let each group run a final test of their design. If a group is unable to finish the primary challenge, it is usually because they needed a few more minutes. Let them know this so they do not feel discouraged.
    b. After each test, have the group go back to their station and clean up by taking apart and re-organizing their mechanical attachments.
    c. Once all of the groups are done cleaning up, give a few pieces of feedback. Explain what you saw went well or went poorly today.
    d. (Optional) Present a misc. engineering item or robotics video
    e. Disperse a homework sheet to each student

Sample Homework Questions:

1. How did you apply what you learned from previous weeks in Lesson Five?
2. What was the most important part of your robot-making process (e.x. iterative process)?
3. What was the hardest part of the Roly-Poly challenge? How did you and your group overcome it?
4. If you could make any kind of robot with the EV3 Mindstorm kits, what would you build?

Lesson Six

Robotics Science Fair

Objective: To allow students to be creative and design a robot of their choice

Lesson Overview: Rather than do a challenge, students will receive the opportunity to design, build, and program a robot from scratch independently. At the end of the session, students will demonstrate their robot to the rest of the class.

Materials:

12 Mindstorm EV3 kits. Set up the 12 kits around the classroom for students to sit with.

- Pre-Built Chassis (x12). 1 chassis per group. Groups of 2-3 students.
- 13 Laptops with the EV3 Mindstorm software (the 13th laptop is for the teacher)
- Projector
- 12 MicroUSB cables (for connecting the brick to the laptop)
- Ultrasonic Sensors (x12) or Infrared Sensors (x12)
- Touch Sensors (x12)
- Light Sensors (x12)

Procedure:

Total length – 1 hour

1. Synopsis of previous week and what will be done this week. 1 minute.
2. Review of design process. 3-4 minutes.
    a. Ask students what robot they would like to make the EV3 mindstorm kits.

"As you may remember from Lesson Two, coming up with a design is a combination of being creative but realistic. Realistically speaking, it is impossible to make an EV3 fly using the kit parts despite it being a creative idea. Creatively speaking, it is not very exciting to make an EV3 chassis which drives forward and then does nothing else, though it is a very reasonable task. I challenge you to find a middle ground – choose a project which will push your abilities and that you will be proud to call your own. Ask yourself what you want your robot to accomplish beyond various movements. Instead of saying, "I want my robot to swing a beam piece up and down," ask, "How can I build a robot which can knock down walls?" From simple questions like those, you can make a fascinating project by asking the kind of questions we went over in Lesson Two. What is the purpose? What resources do I have and to what extent can I use them? How can I split up the larger idea into smaller, simpler parts? What are all the possible prototypes or designs I could make and how could I make them? Which design should I choose and will I be able to finish in time?

In coming up with an idea, today it's up to you. Think of daily nuisances and how an EV3 could solve it on a scaled down basis. Think of impossible scenarios for your robot to traverse. But most of all, make sure to think of the reality. Avoid being paralyzed by the idea of a crazy robot or other overly ambitious venture. Remember, you only have about an hour. And, as we've said from the start of these lessons, simple is often better than complex."

3. Brief review of engineering process. 2-3 minutes.
    a. Iterative Process
    b. "Less is more"
    c. Teamwork
4. Build/Program Session. 40-45 minutes.

Each group will work independently on making a project. During this time, go around from group to group and talk to them about their progress and help as needed.

Help students work together as a team. If an argument gets out of hand, resolve it. If a student feels like they are not contributing, get him or her a task. Keep communication clear between groupmates.

Keep track of which students are working on hardware or software and when. Periodically go around encouraging students to switch up between hardware and software.

Continue emphasizing the iterative process. Tell students to test frequently to work out issues in both hardware and software.

If students have difficulty coming up with an idea after 5 minutes, give ideas for them.

5. Exhibition/Demo Period. ~10-15 minutes.

There are two primary ways to set this part of the lesson up:

a. Each group of students are given a 1-2 minutes to go up in front of the class to explain and demo their robot.
b. Instead of having students go up front, let students freely move around the class and talk to other groups about their robot. Suppose there a groups of two. For half of the exhibition period, half of the students will walk around and the other half will stay with their projects to explain. For the second half of the exhibition period, the partners will switch off and repeat.

It is encouraged to go around taking pictures of each group with their robot to be sent to parents.

6. Final Wrap-Up & Clean Up. Last 5 minutes.
    a. Give a final good-bye to all students
    b. No homework!