UNIVERSITY TRANSPORTATION CENTER FOR
RAILWAY
SAFETY

UTCRS Middle School STEM Curriculum

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Objectives

By the end of the curriculum lessons, the student will be able to:

1. Think critically and find solutions to transportation engineering problems.
2. Work collaboratively in small groups.
3. Use problem-solving skills to read and interpret diagrams to build a robot.
4. Use problem-solving skills to create, run, and test programs developed to control a robot.
5. Plan a route through an obstacle course that is efficient and obeys all traffic and railroad safety signs and signals.
6. Use the color sensor and the touch sensor to build a robot that can follow a line and complete specific activities.
7. Apply principles of logic and critical thinking to find the most effective and efficient way to navigate a maze design.
8. Use variables in the context of programming to determine the state of something, such as “true” or “false”.
9. Understand and utilize the loop constructs in programming.

Texas Essential Knowledge and Skills (TEKS) and National Standards

TEKS Science 6-8

(2) Scientific investigation and reasoning. The student uses scientific inquiry methods during laboratory and field investigations. The student is expected to:

- (A) plan and implement comparative and descriptive investigations by making observations, asking well-defined questions, and using appropriate equipment and technology;
- (B) design and implement experimental investigations by making observations, asking well-defined questions, formulating testable hypotheses, and using appropriate equipment and technology;
- (C) collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers;

(D) construct tables and graphs, using repeated trials and means, to organize data and identify patterns; and
(E) analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.

(6) Force, motion, and energy. The student knows that there is a relationship between force, motion, and energy. The student is expected to:
(A) demonstrate and calculate how unbalanced forces change the speed or direction of an object's motion;
(B) differentiate between speed, velocity, and acceleration; and
(C) investigate and describe applications of Newton's law of inertia, law of force and acceleration, and law of action-reaction such as in vehicle restraints, sports activities, amusement park rides, Earth's tectonic activities, and rocket launches.

(7) Force, motion, and energy. The student knows that there is a relationship among force, motion, and energy. The student is expected to:
(A) contrast situations where work is done with different amounts of force to situations where no work is done such as moving a box with a ramp and without a ramp, or standing still;

(8) Force, motion, and energy. The student knows force and motion are related to potential and kinetic energy. The student is expected to:
(A) compare and contrast potential and kinetic energy;
(B) identify and describe the changes in position, direction, and speed of an object when acted upon by unbalanced forces;
(C) calculate average speed using distance and time measurements; and
(D) measure and graph changes in motion.

(11) Underlying processes and mathematical tools. The student applies ***Grade 6*** mathematics to solve problems connected to everyday experiences, investigations in other disciplines, and activities in and outside of school. The student is expected to:
(A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;
(B) use a problem-solving model that incorporates understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;
(C) select or develop an appropriate problem-solving strategy from a variety of different types, including drawing a picture, looking for a pattern, systematic guessing and

checking, acting it out, making a table, working a simpler problem, or working backwards to solve a problem; and

(D) select tools such as real objects, manipulatives, paper/pencil, and technology or techniques such as mental math, estimation, and number sense to solve problems.

TEKS Math 6-8

(9) Expressions, equations, and relationships. The student applies mathematical process standards to use equations and inequalities to represent situations.

(10) Expressions, equations, and relationships. The student applies mathematical process standards to use equations and inequalities to solve problems.

(12) Measurement and data. The student applies mathematical process standards to use numerical or graphical representations to analyze problems.

(14) Underlying processes and mathematical tools. The student applies mathematics to solve problems connected to everyday experiences, investigations in other disciplines, and activities in and outside of school. The student is expected to:

(A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;

(B) use a problem-solving model that incorporates understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;

(C) select or develop an appropriate problem-solving strategy from a variety of different types, including drawing a picture, looking for a pattern, systematic guessing and checking, acting it out, making a table, working a simpler problem, or working backwards to solve a problem; and

(D) select tools such as real objects, manipulatives, paper/pencil, and technology or techniques such as mental math, estimation, and number sense to solve problems.

International Technology and Engineering Educators Association (ITEEA) Standards
Grades 6-8

Standard 2. Students will develop an understanding of the core concepts of technology.

- Technological systems can be connected to one another.
- Malfunctions of any part of a system may affect the function and quality of the system.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

- Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.

Standard 9. Students will develop an understanding of engineering design.

- Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

- Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.
- Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.
- Some technological problems are best solved through experimentation.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

- Use information provided in manuals, protocols, or by experienced people to see and understand how things work.
- Use tools, materials, and machines safely to diagnose, adjust, and repair systems.
- Use Laptops and calculators in various applications.
- Operate and maintain systems in order to achieve a given purpose.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

- Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology.
- Identify trends and monitor potential consequences of technological development.
- Interpret and evaluate the accuracy of the information obtained and determine if it is useful.

National Science Education Standards

Content Standard A:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B:

- Properties of objects and materials
- Forces and motion
- Electricity and magnetism
- Transfer of energy

Content Standard E:

- Abilities of technological design
- Understanding about science and technology

Content Standard F:

- Science and technology in local challenges
- Science and technology in society

Day 1 - A Future in Engineering

Activity #1

Estimated Time: 10 min

Title: Introductions and Assign Students to Groups

Lesson Overview: Students will learn about transportation engineering and will be assigned to groups.

Objectives:

1. Explain what the term "transportation engineering" means.
2. Describe what a transportation engineer does.
3. State the average salary for a transportation engineer.
4. Describe the educational requirements needed to become a transportation engineer.
5. Explain what "railway engineering" is.
6. Describe what a railway engineer does.
7. State typical salary of a railway engineer.
8. Describe the educational requirements needed to become a railway engineer.

Lesson Flow:

1. Welcome: During the introduction you want to get kids excited about the curriculum lessons and what they are about to learn. Mention some of the projects students will be building, the daily challenges and the "Grand Challenge". Introduce yourself and tell students a little about yourself.
2. Show video of the LEGO® EV3: https://www.youtube.com/watch?v=cXgB3IIvPHI
3. Agenda: Go over the agenda for the day so students know what is going to happen.

Activity #2

Estimated Time: 20-30 minutes

Title: Sample Icebreaker – Beach Ball Toss

Lesson Overview: Students will engage in an icebreaker.

Materials Needed: (per class)

- Beach ball
- Markers

Lesson Flow:

1. In this game, you use a beach ball with the following questions written all over the ball. The idea is to have students stand in a circle and toss it to one another and the person who catches it must say their name and answer the question under their right thumb.
2. Give students directions for the game and show them the beach ball. Point out how it has questions written all over it. To start the game, the teacher makes the first toss. Continue playing for 20-30 minutes until everyone has had a chance to speak. Have the beach ball or balls ready prior to the start of the camp so you do not have to worry about writing the questions all over the beach ball at the beginning of the game. Choose what you will write on the ball from the following list of questions:
    a. *Where do you go to school?*
    b. *What grade are you in?*
    c. *What is your favorite food?*
    d. *What is your favorite video game?*
    e. *What do you like to do for fun?*
    f. *How many brothers and sisters do you have?*
    g. *Who is your favorite singer or band?*
    h. *Do you like sports, which ones?*
    i. *How many pets do you have and what are their names?*
    j. *What hobbies do you have?*
    k. *What college do you want to go to?*
    l. *Where would you go for your dream vacation and why?*
    m. *What do you want to be when you grow up?*
    n. *What do you like the most about yourself (cannot be a physical characteristic)?*
    o. *What is your favorite T.V. show?*
    p. *What is one thing you would like to change about yourself (cannot be a physical characteristic)?*
    q. *What subject do you like best in school and why?*
    r. *Who is the smartest person you know?*
    s. *Are you a morning person or a night owl?*
    t. *What has been your proudest accomplishment so far?*

Activity #3

Estimated Time: 10 minutes

Title: Scavenger Hunt – Transportation Engineering

Lesson Overview: Students will complete an online scavenger hunt. Using Google or any search engine, students are to look up questions to help them learn about transportation engineering.

Objectives:

1. Learn what the term "transportation engineering" means.
2. Describe what a transportation engineer does.
3. State the average salary for a transportation engineer.
4. Explain:
   a. The educational requirements needed to become a transportation engineer.
   b. What "railway engineering" is and what a railway engineer does.

Materials Needed: (per group)

- Scavenger Hunt Worksheet (available in *Appendix A.1*)
- Laptop
- Journal (per student)

Lesson Flow:

1. Have students work in teams and search for answers of scavenger hunt worksheet.
2. Have students look up the following questions in Google or any search engine available for use by the students. Have them write down the answers to each question below:
   a. *What is transportation engineering?*
   b. *What does a transportation engineer do?*
   c. *What are the specialties within transportation engineering?*
   d. *What type of degree does a person need to become a transportation engineer?*
   e. *What kind of courses should you take in high school if you want to become an engineer?*
   f. *What is the average salary of a transportation engineer?*
   g. *What is railway engineering?*
   h. *What does a railway engineer do?*
   i. *What is the average salary for a railway engineer?*

Activity #4

Estimated Time: 5 minutes

Title: Assign Team Roles

Lesson Overview: Students will be assigned to groups and roles within groups to create teams of engineers**.**

Objectives:

1. Understand how engineers work in teams to achieve a goal.
2. Learn the importance of each member's role and assuming role functions.
3. Learn to assign tasks based on goals and needs of a team.

Materials Needed:

- No materials needed

Lesson Flow:

1. Make sure that students are in groups of 4-5.
2. Have students discuss and decide who will serve in each of the roles. Roles include:
    a. One lead engineer,
    b. 2-3 assistant engineers, and
    c. 1-2 programmers (programmers will not be needed until Activity #6).
3. Assure students that everyone will get the chance to be in each of the roles at least once.

Activity #5

Estimated Time: 40 minutes

Title: Assemble LEGO® MINDSTORM® EV3 Basic Robot

Lesson Overview: Students will work in teams modeling real-life engineering working groups, assuming team roles as assigned in Activity #4. Students will follow the basic instructions for building and programing their own robot.

Objectives:

1. Describe the educational requirements needed to become a railway engineer.
2. Learn to assume roles and interact in a team to achieve a goal.
3. Use problem-solving skills to read and interpret constructing a basic robot from the LEGO® MINDSTORM® EV3 kit manual provided (pg. 7-38.)

Materials Needed: (per group)

- One pre-assembled LEGO® MINDSTORM® EV3 robot (one per class to show students the final result)
- One LEGO® MINDSTORM® EV3 robotics kit
- LEGO® MINDSTORM® EV3 manual
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Meter stick
- Black masking tape or vinyl electrical tape to delineate the challenge course
- Journal (per student)

Lesson Flow:

1. Relate to students that they are going to be working with robots to learn more about transportation engineering.
2. Get them excited by telling them they will be building and programming their own robot by showing students a completed basic robot. Pass it around the room until all teams have examined it.
3. Show students the directions for building the basic robot in the LEGO® MINDSTORM® EV3 manual (pg. 7-38).
4. Tell students that for each round of three steps, they will be changing roles:
    a. The function of the "lead engineer" is to construct the robot. The rest of the team will be "assistant engineers". Assistants look for parts and help the lead engineer.
    b. Emphasize that there are about 600 pieces in each robot kit. Those functioning as "assistant engineers" have the responsibility to manage pieces, including taking care to not lose or misplace any of the parts.

Activity #6

Estimated Time: 15 minutes

Title: Programming Basics

Lesson Overview: Teams will learn the basics of programming by becoming familiar with LEGO® MINDSTORM® EV3 programming.

Objective:

1. Use problem solving skills to create, test, and run programs available to control a robot.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robot
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Journal (per student)

Lesson Flow:

1. Using the straight move program in the software manual, review the following basic commands with students: (See *Appendix A.4* for programming block information and command guides, and *Appendix A.5* for the Line Follower Program)
    a. Start command – green arrow. All programs must use this as their first block!
    b. Move steering block: demonstrate each of the following commands – rotations on/off, steering, power, # of rotations, and break/coast at end.
    c. Wait for students to familiarize themselves with using the block with sensors and other programming basics.
    d. Review sensors: Color, Gyro, Ultrasonic, Touch

Activity #7

Estimated Time: 30 minutes

Title: Program Your Robot

Lesson Overview: Teams will learn the basics of programming.

Objective:

1. Use problem solving skills to create, test, and run programs created to control a robot.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Journal (per student)

Lesson Flow:

1. Before programming the commands, connect the robot to a laptop using the cable provided. Press the button in the middle of the block to turn it on.
2. First, program the LEGO® MINDSTORM® EV3 robot to move in a straight line for one meter. Once all teams have accomplished this task, program LEGO® MINDSTORM® EV3

robot to move forward for one meter, wait one second, then move backwards in a straight line for two meters.

3. To see an example in the LEGO® MINDSTORM® EV3 Software, look at Robot Educator → Basics → Straight Move.
4. Have students test their program after the addition of every block to make sure each command is programmed correctly.

Challenge #1

Estimated Time: 45 minutes

Title: You're the Engineer!

Lesson Overview: Teams will learn engineering problem solving through role-play.

Objective:

1. Learn about real-life applications of LEGO® MINDSTORM® EV3 programming by using a role-play challenge.
2. Review concepts of speed (average vs. instantaneous) and velocity.

Materials Needed: (per group)

- LEGO® MINDSTORM® EV3 constructed robot
- LEGO® MINDSTORM® EV3 manual
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Black masking tape or vinyl electrical tape to delineate the challenge course
- Journal (per student)

Lesson Flow:

1. Each team will need one other assistant to play the part of the newly hired engineer. The teacher or facilitator will be the "boss".
2. Read the following scenario to the students:
   a. Suddenly the phone rings:
      "This is your boss. Listen, we have an emergency situation. There has been a train derailment at Closner and Business 107. We need you out there ASAP. The rest of your team is on the way. I need you to take photographs of the derailment, conduct a full investigation, and

interview the driver and any key witnesses. Please have all of this in a report ready for me at 8:00 am sharp!"

b. You, the engineer:
"Oh my gosh; I cannot have the report ready by 8:00 am; what is he thinking?!"

c. Engineer: (Pondering the matter, looking up with her hand on her chin.)
"Wait a minute, maybe I can call on my assistant (at this point each group should name their robot). Yeah, I'll send him out there to take pictures and do the investigation, that way, the only thing I have to do is write the report."

d. Engineer:
"Robot, it's time to wake up. I've got a job for you. See this layout? Well, I need you to get from here to the derailment. Don't worry I will guide you along the way."

Directions:

1. To begin, have students tape out the route from point A (your house) to point B (accident scene) on the floor with electric tape.
2. First task: figure out how long the entire route is. Add up the distance the robot needs to travel.
3. Second task: determine the speed of the robot. To do this, program your robot to move forward for 5 seconds. Place the robot on the floor with a meter stick by the side of the robot and mark the starting point (back of the robot); move the robot forward for 5 seconds and mark the ending point (back of the robot). Divide the number of meters traveled by 5 to get the average speed in meters/second [m/s].
4. Concept review, ask students:
   a. W*hat are you measuring?* (average speed)
   b. *What is the difference between average and instantaneous speed?*
   c. *Using the given route, how long will it take your robot to get from point A to point B (that is from home to the accident site)?*
5. Third task: program the robot to move along the provided route as quickly and safely as possible.
   <u>Hint:</u> Make sure that students know that there is more than one way to program robots. Take the time to have students plan how their team will program their robot. Have

them work through the commands and the order of commands they will use to program their robot.

6. Have teams run their LEGO® MINDSTORM® EV3 robot through the route marked on the floor. They will need to keep track of the time it took for their robot to complete the route, as well as the turns the robot makes.
7. Following the challenge, review the time each group took to get from one end to the other. Determine if they made the correct turns or not. Provide feedback on programming and calculations.
8. Select the winners of Challenge #1: select the team that navigated their robot through the route with all of the correct turns, in the shortest time, and with no safety issues.

Activity #8

Estimated Time: 15 minutes
Title: Clean-up and Closing Discussion
Lesson Overview: Have students reflect on the challenge at hand and other challenges real transportation engineers face on a daily basis.
Objectives:

1. Count and clean all material used.
2. Reflect on student understanding of transportation engineering real-life challenges.

Materials Needed:

- No materials necessary

Lesson Flow:

1. Have a discussion about the challenges real engineers would face if they encountered a situation as in the last activity. What possible solutions do they suggest to solve this situation?
2. Make sure students count and put all materials back in the box and that no Lego parts are missing, misplaced, or left behind.

Day 2 - Bumper Cars

Activity #1

Estimated Time: 30 minutes

Title: Using the Touch Sensor/Assembling a Bumper Car

Lesson Overview: Teams will learn advanced programming skills needed for engineering-based problem-solving.

Objectives:

1. Use problem solving skills to create, run, and test programs created to control a robot.
2. Plan a route through an obstacle course that is efficient and obeys all traffic and railroad safety signs and signals.
3. Use the color sensor and the touch sensor to build a robot that can follow a line, and use the touch sensor as a guide to achieve specific commands.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit
- One LEGO® MINDSTORM® EV3 Manual
- Laptop
- LEGO® MINDSTORM® EV3 software installed on the laptop
- Black masking tape or vinyl electrical tape to delineate the challenge course
- Journal (per student)

Lesson Flow:

1. The touch sensor is one of the most common sensors used. Have students add the touch sensor to the front of the robot by following LEGO® MINDSTORM® EV3 manual pages 77-80.
2. Tell students that they are to program the robot to move in a straight line. When the robot encounters an obstacle, it is to stop, backup a short distance, make a sharp right turn and continue moving forward. (The obstacle can be a book, foot, student hand, etc.)
3. Let students know that they will use this robot in a game of bumper cars in Activity #2. A reference Bumper Car program is available in *Appendix A.6*.

Activity #2

Estimated Time: 30 minutes

Title: Let's Play Bumper Cars

Lesson Overview: Students program their robots to use the touch sensor for the bumper car activity.

Objective:

1. Use problem-solving skills to create, test, and run programs created to command a robot.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit constructed

Lesson Flow:

1. Have each team bring their car to the center of the class to play bumper cars with the other cars.
2. The cars should not hit each other forcefully, since they have a built in touch sensor. Allow students to have fun with this activity.

Activity #3

Estimated Time: 75 minutes

Title: Build and Program the Line Follower

Lesson Overview: Students will use their knowledge and the color sensor to program their robot to follow a line smoothly.

Objective:

1. Use problem solving skills to create, test, and run programs created to control a robot.

Materials Needed: (per group)

- Colored electric tape
- Programmed robot with color sensor
- Journal (per student)

Lesson Flow:

1. Explain to students that they are going to use the color sensor to teach their robot to obey safety signs and signals.

2. Tell students their next challenge will be to program their LEGO® MINDSTORM® EV3 robot to follow a line along a curved path and respond to different colors on the test path.
3. Show students a video of the "Line Follow" and "Smooth Follow" programs on YouTube https://www.youtube.com/watch?v=ODAGVeeDagk.
4. For programming purposes, provide the students with a copy of the Line Follower Program listed in *Appendix A.5*.
   Note: All of the commands in this program are inside a loop: the color sensor is set to measure reflected light intensity, the math blocks are set to advanced, the upper variable blocks are set to write numeric (default), the lower variable blocks are set to read numeric, and the move tank block is set to on. On the formula spaces, the formula is *(a-b)*c*.
5. Have students program by the color of obstacles and the route colors.
6. Have students test their program after the addition of each block to make sure each command is programmed correctly.

Activity #4

Estimated Time: 15 minutes
Title: Clean-up and Closing Discussion
Lesson Overview: Have students reflect on the challenges real transportation engineers face on a daily basis.
Objectives:
1. Understand the importance of traffic signs and signals.
2. Reflect on safety and the need for traffic signs and signals in transportation.
3. Count and clean all material used.

Lesson Flow:
1. Have a discussion about the challenges real engineers would face if they encountered a situation as in the last activity, and other possible solutions they might come up with to solve this situation.
2. Make sure students count and put all materials back in the box and Lego parts are not misplaced, left behind, or missing.

Day 3 - Safety Rules!

Activity #1

Estimated Time: 60 minutes

Title: Know Your Signs

Lesson Overview: Students will learn about signs and their meanings.

Objectives:

1. Identify and interpret all passive railway safety signs.
2. Distinguish between "passive" and "active" signs and signals.

Materials Needed: (per group)

- One poster board or construction paper (whichever is available)
- Popsicle sticks
- Cutout of safety signs available in *Appendix A.2* or at: http://oli.org/education-resources/safety-tips/know-your-rails-signs-and-signals
- Ziploc bag
- One Safety worksheet per student (available in *Appendix A.3*)
- Journal (per student)

Lesson Flow:

1. Ask students to share the usual route they take to school. Then, ask if they crossed any train tracks on the way. Engage them in further dialogue about the types of signs they noticed at a railroad crossing.
2. Show the video of train accident in which a person tried to get around the train tracks even though the lights were flashing. Go to: http://www.cnn.com/video/data/2.0/video/us/2014/04/03/lv-vo-train-slams-into-suv.cnn.html.
   View the video and engage the students in a discussion about the video.
3. Go to http://oli.org/education-resources/safety-tips/know-your-rails-signs-and-signals and show the students the various railway safety signs.
4. Tell students they are going to learn about the different safety signs in a group activity. Assign every group a sign to present to the class. They must create a sign out of poster board (or construction paper) and popsicle sticks and present their sign to the class, providing the name and the purpose of the sign.

5. Cut out the signs found in *Appendix A.2*. Fold up the papers and place them in a Ziploc bag. Have each group select a sign to present. Tell students they can go to http://oli.org/education-resources/safety-tips/know-your-rails-signs-and-signals for information about their sign.
6. Give each group a few minutes to make their presentation to the class. While each group is presenting, have students complete the "Safety Signals Worksheet". Under each sign, they must write down the name of the sign and what the sign means.
7. At the conclusion of the group presentations, tell students that the type of signs they were assigned were "passive" signs. Point out that there are also "active" signs. Go to http://oli.org/education-resources/safety-tips/know-your-rails-signs-and-signals and click on "Learn More" under "Devices at the Crossing". Discuss the flashing red lights, the bells, the gate, and the cantilever. Point out that the bells and flashing red lights are active signs.

Activity #2

Estimated Time: 50 minutes
Title: Be a Safe Driver
Lesson Overview: Students will program their robot to follow traffic signals.
Objectives:

1. Recognize and interpret traffic signs and signals.
2. Recognize and interpret railway safety signs and signals
3. Plan a route through an obstacle course that is efficient and obeys all traffic and railroad safety signs and signals.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit
- LEGO® MINDSTORM® EV3 manual
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Journal (per student)

Lesson Flow:

1. Ask students to name and count the number of signs on the road they see every day when driving with their parents. Engage them in a dialogue about safe driving.

2. Using a sheet of chart paper have them name some of the “do’s and don’ts” of the road, writing down their responses in one of two columns.
3. After they offer all of their responses, discuss the issue of safe driving. Tell them that they are going to program their bumper car to obey traffic safety rules.
4. Begin by talking about the basic traffic signs and laws such as: stopping at a stop sign, slowing down at a yellow light, slowing down in a school zone, and stopping when the gates are down at a railroad crossing.
5. Explain that they will learn to use the color sensor for safety. To use the sensor, each team should position the color sensor on their robot so that the sensor is at a right angle, approximately 1 cm from the surface of the test path.
6. Print out the rectangles in *Appendix A.9* on a color printer and tape to a sheet of chart paper.
7. Help students program their robot to keep going at a green light, slow down at a yellow light, and stop at a red light. See Robot Educator or YouTube for programming instructions (https://www.youtube.com/watch?v=wvE5iXktVsY). A color sensor program is available in *Appendix A.7*. The Color Sensor Programing is inside a loop. A switch block is placed inside the loop and set to measure color with the color sensor. At the top, the no color tab is selected as default, and the default action is selected. In this case, we set it to move both motors at 50% power. Then, the specified actions are moved to each color.

Challenge #2

Estimated Time: 35 minutes
Title: Accident Investigation Team
Lesson Overview: Students will be problem-solving using formulas.
Objective:

1. Review concepts of speed (average vs. instantaneous) and velocity.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit
- LEGO® MINDSTORM® EV3 manual
- Laptop
- LEGO® MINDSTORM® software installed on the laptop

- Journal (per student)

Lesson Flow:

1. Turn to class and say:
   "Students, I have some great news, it seems you all have been chosen to participate in a summer internship at a railway safety company called "United Safety Rail" (USR). They want to pay you $30,000 to be on their Accident Investigation Team. Recently, there was an accident – a driver was texting and didn't see a train coming! The USR would like you and your team to investigate. They want you to recreate the scene of the accident."
   This is the official report:
   "The accident occurred when Britney was in her car texting her friends about going to the beach on Friday. She never looked up to see that the train was right in front of her standing at the tracks. She hit the side of the train, luckily she was not going too fast (~35 mph), so while the front end of her car was damaged, she did not get hurt. The USR would like for you to recreate the scene of the accident and determine the force with which the car hit the train and fill out an Accident Investigation Report."

Challenge Directions:

1. Have students program the robot to move forward in a straight line and bump into a stationary object (This object represents the stationary train; it can be anything as long as it is heavy enough to stay immobile when the robot hits it).
2. First, students need to know the speed of the robot. However, this is a challenge. The motion connector does not tell you the speed of the robot. Prompt students to use their problem-solving skills to determine the speed of the robot. Discuss student responses.
3. Engage students in a discussion about the circumference and the diameter of a wheel, then have them measure the diameter of the wheel and compute circumference using the formula:

$$Circumference = \pi \times diameter$$

4. Once students have computed the circumference, have them determine the speed of the vehicle using the formula:

$$Speed = RPM \times Circumference$$

5. Based on the program students created in step 1, have them compute the speed at which the robot was traveling.
6. Now students add a second motion block to have the car accelerate as it nears the train. Have students compute the speed of the robot based on the second motion block.
7. Before students can use the equation $F = m \cdot a$; they must determine the mass of the robot. Have students use a scale to find out the mass of the robot.
8. Refer to Newton's second law; discuss the equation $F = m \cdot a$ then introduce the second version of the equation:

$$F = m\frac{(v_f - v_i)}{t}$$

9. Have students compute the force exerted on the stationary "train". Have students fill out the relevant sections of the Accident Investigation Report available in *Appendix A.10*.

Activity #3

Estimated Time: 15 minutes
Title: Clean-up and Closing Discussion
Lesson Overview: Have students reflect on the challenges real transportation engineers face on a daily basis.
Materials Needed:

- No materials necessary.

Lesson Flow:

1. Have a discussion about the challenges real engineers would face in the last scenario, and the possible solutions they might have to come up with.
2. Make sure students count and put all materials back in the box and that Lego parts are not misplaced, left behind, or missing.

Day 4 - All in a Day's Work

Activity #1

Estimated Time: 20 minutes

Title: Newton's Second Law

Lesson Overview: Students will work on a worksheet to practice problems for Newton's second law.

Objective:

1. Use the formula [$F = m \cdot a$] to solve various real-world application problems.

Materials Needed: (per group)

- Worksheet: Practice Problems for Newton's Second Law of Motion (*Appendix A.11*)
- Journal (per student)

Lesson Flow:

1. Have students separate into groups and work on the worksheet

Activity #2

Estimated Time: 45 minutes

Title: Build and Program a Forklift

Lesson Overview: Students will build a forklift using the LEGO® manual. They will program the forklift to lift a box and drop it off at a designated drop-off area.

Objective:

1. Use problem-solving skills to create, test, and run programs created to control a robot.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit manual
- LEGO® MINDSTORM® EV3 kit
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Object to be moved
- Journal (per student)

Lesson Flow:

1. Use the LEGO® manual to build a forklift robot (pages 54-68).

2. Show the objects that students must move from location A to location B.
3. Have the students write a program to use the forklift. This program is completely open-ended, and many sensors can be used in conjunction with the forklifting action. A small and simple program found in *Appendix A.8* illustrates the use of the medium motor block as the means to drive the lifting and lowering mechanism.

Activity #3

Estimated Time: 10 minutes
Title: Energy, Work, and Power
Lesson Overview: Teams will use their forklift to determine the amount of energy, work, and power performed during a task.
Objectives:

1. Use the programmed forklift to perform a specified task.
2. Determine the amount of energy, work, and power needed to perform the specified task.

Materials Needed: (per group)

- Small scale
- Forklift box (made from Lego pieces, about 10 cm^3)
- Robot with Forklift Program
- five small objects that fit on the forklift box
- Small scale
- Journal (per student)

Lesson Flow:

1. Ask students what they think about when they hear the word "energy."
   a. *How do you use energy in your life?*
   b. Can you name a few things that we do that use energy?
   c. *What happens when we don't have enough energy?*

   Tell students that although we have an everyday definition for energy, there is also a scientific definition.

   Energy: *Energy is the capacity of a physical system to perform* ***work.*** *Energy exists in several forms such as* ***heat****,* ***kinetic****,* ***potential energy****, mechanical energy, light, electrical energy, or other forms.*

2. Introduce the terms force, work, energy, and power. Give some everyday examples of each term.
3. Explain the formulas for computing force, work, and power.
   a. *Force = mass × acceleration*
   b. *Acceleration due to gravity (9.81 m/s²)* — $9.81\ m/s^2$
   c. *Energy is the ability to do work.*
   d. *Work is force acting over a distance to move an object.*
   e. *Work = force × distance*
   f. *Power is how fast work can be done (or the rate at which work is done).*
4. Tell students to place different objects in the box that they built as part of the Forklift robot. It does not matter what is placed in the box as long as the objects are small enough to fit inside.
5. Use a scale to determine the weight of the box with the objects inside.
6. Using their program, tell students to use the forklift to lift the box with objects off the ground and take it from point A to point B. Tell students to do the following:
   a. Obtain the time it took to lift the object by setting the duration of the motion block (in seconds).
   b. Measure the distance the object was moved.
   c. Now that they have the mass of the box with objects, the distance it was lifted off the ground, and the time it took to lift the box off the ground, compute the force, work, and power needed to move the box. Have students use the following equations for their calculations:

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$\text{Work} = \text{force} \times \text{displacement}$$

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

Challenge #3

Estimated Time: 10 minutes
Title: Summer Job!
Lesson Overview: Students will be given a challenge of moving objects from point A to point B using their programmed forklift.
Materials Needed: (per group)

- Worksheet, Time to Deliver Table (*Appendix A.12*)
- Small scale
- Forklift box (made from Lego pieces, about 10 cm^3)
- Robot with forklift program
- five small objects that fit on the forklift box
- Black masking tape or vinyl electrical tape to delineate the challenge course
- Prize for winning team: to be determined by teacher
- Journal (per student)

Lesson Flow:

1. It happened again! The CEO of "*On the Move*" found out about the great work you are doing at the University Transportation Center for Railway Safety (UTCRS) and she wants you to head the transportation-engineering department. "*On the Move*" is a company that has an entire fleet of trucks to deliver goods around the U.S. One of their biggest clients is a grocery store chain that has one main warehouse and stores all over the United States. "*On the Move*" is responsible for picking up goods at the warehouse and delivering them to local stores around the nation.
2. Employees who work for "*On the Move*" have different loads to transport. You will have five different loads you need to transport from point A to point B. Arrange the different objects in small boxes that the teams have to transport from one part of the classroom to another.
3. As the head of the transportation-engineering department, one of your responsibilities is to determine how much to charge based on the weight of the load and the distance from the warehouse to the delivery location.
4. To determine the time taken to complete each delivery based on the distance and mass of the load, have each team fill out the "Time to Deliver Table" available in *Appendix A.12*.
5. Each team must map out (with black tape) the distances in inches shown in the table (all originating from the same point – the warehouse) and create loads of various masses based on the mass of the loads shown in the table provided in *Appendix A.12*. The power for all trucks should be set to 75 in the "move" block.

5\. Reward time management by giving the first team to complete the Time to Deliver Table a prize (prize to be determined by teacher).

Day 5 – Railway Safety Freestyle Design Challenge

Activity #1

Estimated Time: 90 minutes

Title: Final Design Challenge – Railway Safety Freestyle!

Lesson Overview: Teams will use their creativity and the knowledge of engineering and programming in a freestyle design challenge to solve railway transportation issues.

Objective:

1. Apply principles of engineering and programming to design their own transportation safety LEGO® MINDSTORM® EV3 robot.

Materials: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit
- LEGO® MINDSTORM® EV3 manual
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Meter stick
- Black masking tape or vinyl electrical tape to delineate the challenge course
- My Robot – Grading Rubric (*Appendix A.13*)
- Journal (per student)

Lesson Flow:

1. The final challenge will be to build a robot and program it to have at least two mechanisms in place. This is designed to be an open-ended challenge. Show the "My Robot – Grading Rubric" provided in *Appendix A.13* to the students. Explain about the final competition and the selection criteria to be used during Activity #2 for selecting the winning team.
2. **Begin Challenge**: ***How will your robot be used in railway safety?*** Example, robot will prevent vehicles from crossing a railroad when a train is approaching.
3. Guide students to use their creativity and imagination, coupled with all of the engineering concepts and knowledge they have gained about transportation issues to build and program a robot that addresses one (or more) transportation safety issue(s).

Activity #2

Title: Continuation of Challenge #3 **“**Summer Job!”

Estimated Time: 1 hour

Title: Run your Program!

Lesson Overview: Teams will present their solutions to railway transportation issues to the class.

Objective:

1. Apply principles of engineering and programming to design their own transportation safety LEGO® MINDSTORM® EV3 robot.

Materials Needed: (per group)

- One LEGO® MINDSTORM® EV3 robotics kit
- LEGO® MINDSTORM® EV3 manual
- Laptop
- LEGO® MINDSTORM® software installed on the laptop
- Meter stick
- Black masking tape or vinyl electrical tape to delineate the challenge course
- Journal (per student)

Lesson Flow:

1. Have every team of students run their program and explain the benefits of their invention in railway safety to the teacher or ‘boss’.
2. If needed, assign a time limit for the presentation.

Activity #3

Estimated Time: 20 minutes

Title: Clean-up and Closing Discussion

Lesson Overview: Have students reflect on the challenges real transportation engineers face on a daily basis.

Lesson Flow:

1. Have a discussion about the challenges real engineers would face in the last activity, and the possible solutions they might have derived.

2. Make sure students count and put all materials back in the box and Lego parts are not misplaced, left behind, or missing
3. Announce the winning team, and let them know that they will be advancing to an overall competition (if there is an overall competition). Otherwise, announce the 1^{st}, 2^{nd}, and 3^{rd} place winners.

Appendices

Appendix A. Worksheets and Guides

Appendix A.1 Scavenger Hunt Worksheet – Transportation Engineering

To complete this online scavenger hunt use Google or any search engine you like and look up the following questions. Write down the answers below each question.

1. What is transportation engineering?

2. What does a transportation engineer do?

3. What are the specialties within transportation engineering?

4. What type of degree does a person need to become a transportation engineer?

5. What kind of courses should you take in high school if you want to become an engineer?

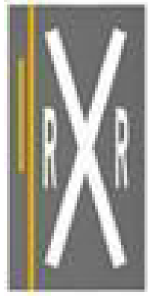
6. What is the average salary of a transportation engineer?

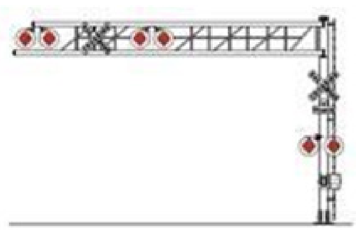
7. What is railway engineering?

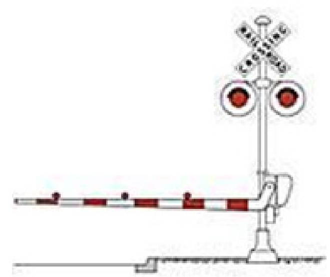
8. What does a railway engineer do?

9. What is the average salary for a railway engineer?

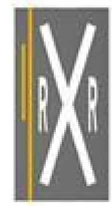
Appendix A.2 Safety Signs and Signals

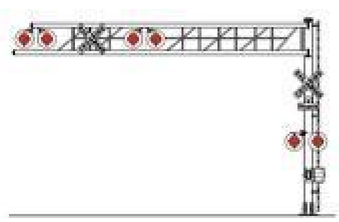


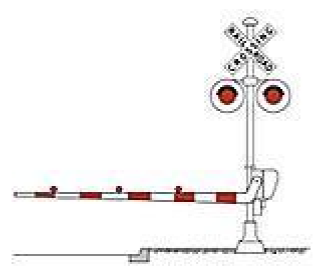




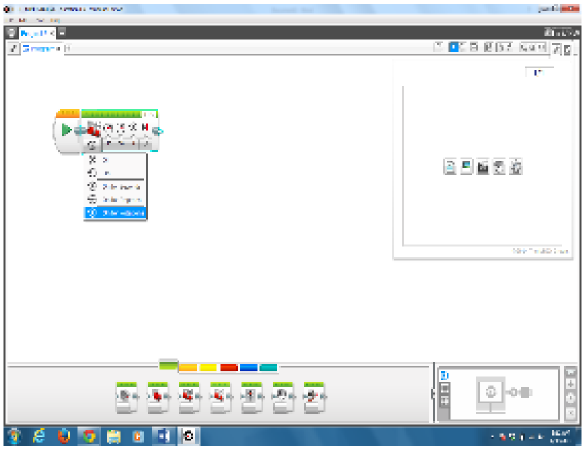
Appendix A.3 Safety Signals Worksheet





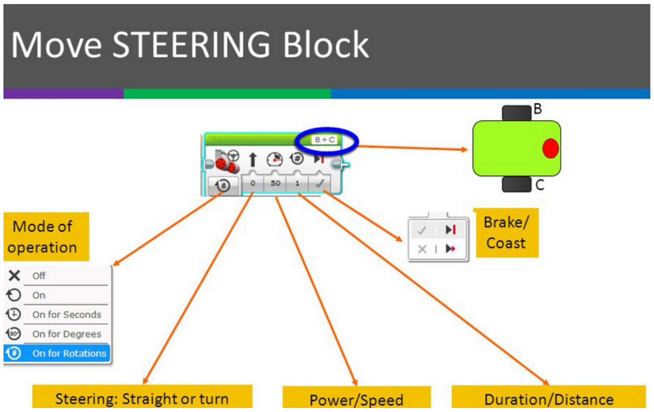


Appendix A.4 Basics of the Move STEERING Block



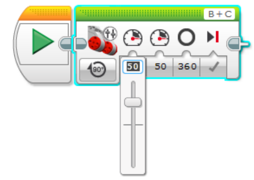
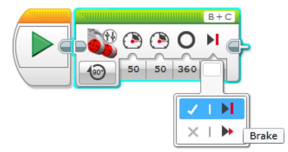
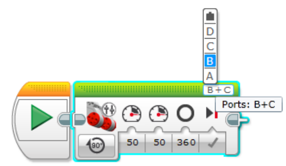
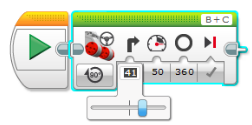
All programs must start with the **Start command**. It is the green arrow.

The **Move STEERING Block** is used to make the robot drive forward, backward, turn, or stop. It also adjusts the steering to make your robot go straight, drive in arcs, make tight turns or spin turns.



The first button on the **Move STEERING Block** determines its main function; motors off, on, on for so many seconds, so many degrees of rotation, or on for so many rotations. The number of seconds, rotations, and degrees are specified on the third button. The buttons are explained in Table 1 below.

Table 1. Move STEERING Block button explanations.

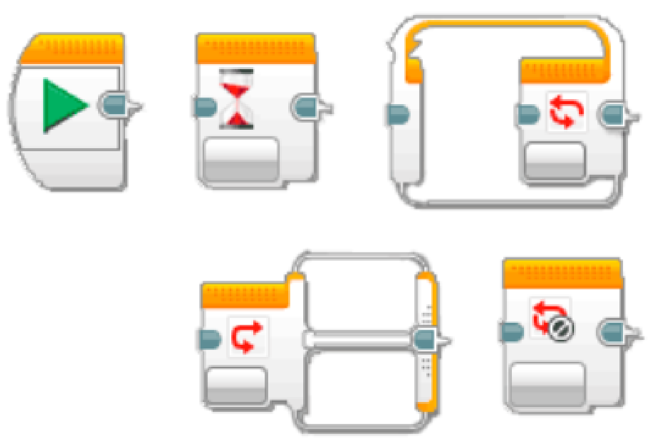
The second and third buttons specify the amount of power from the first and second motor, respectively. Default power is 50 percent. The motors are specified in the box on the upper right hand and explained below.	
The fourth button is the place to specify the numb of seconds, rotations, or degrees that the motors should execute.	
The function of the fifth button is to specify what happens after the task is performed; should the motor stop after the task, or should it let the built momentum follow its course. For most tasks, the brake function is recommended.	
The top right box is the place to specify which motors will be used by this block.	
This is the steering block. It is operated exactly the same as the move tank block with the exception of the steering button. This button specifies the direction of the turn, and how wide or tight the turn should be.	

There are a wide variety of blocks available in the development environment to program LEGO® MINDSTORM® EV3 robots. They can be categorized as Action Blocks (Green), Flow Blocks (Orange), Sensor Blocks (Yellow), Data Operation Blocks (Red), and Advanced Blocks (Blue). The following images show the five types of programming blocks available.

ACTION BLOCKS (Green)

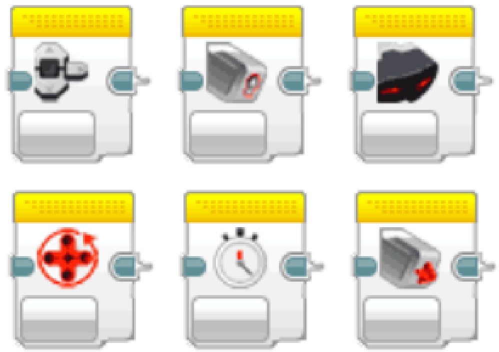
The action blocks control the actions of the program. They control motor rotations and also image, sound and the light on the EV3 P-brick.

FLOW BLOCKS (Orange)



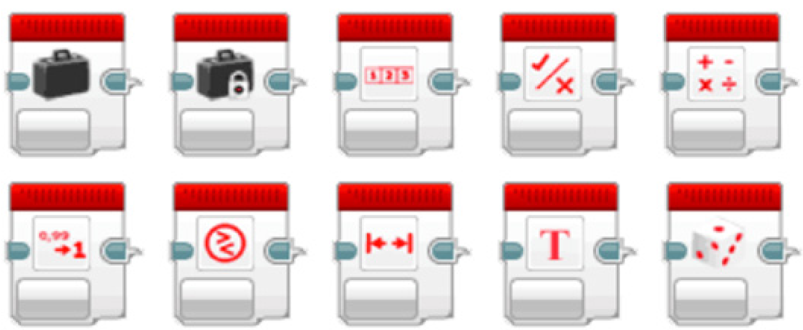
The Flow blocks control the flow of the program. All programs you create will start with the start block.

SENSOR BLOCKS (Yellow)



The Sensor blocks allows your program to read the inputs from the Color sensor, IR sensor, Touch sensor and much more.

DATA OPERATION BLOCKS (Red)



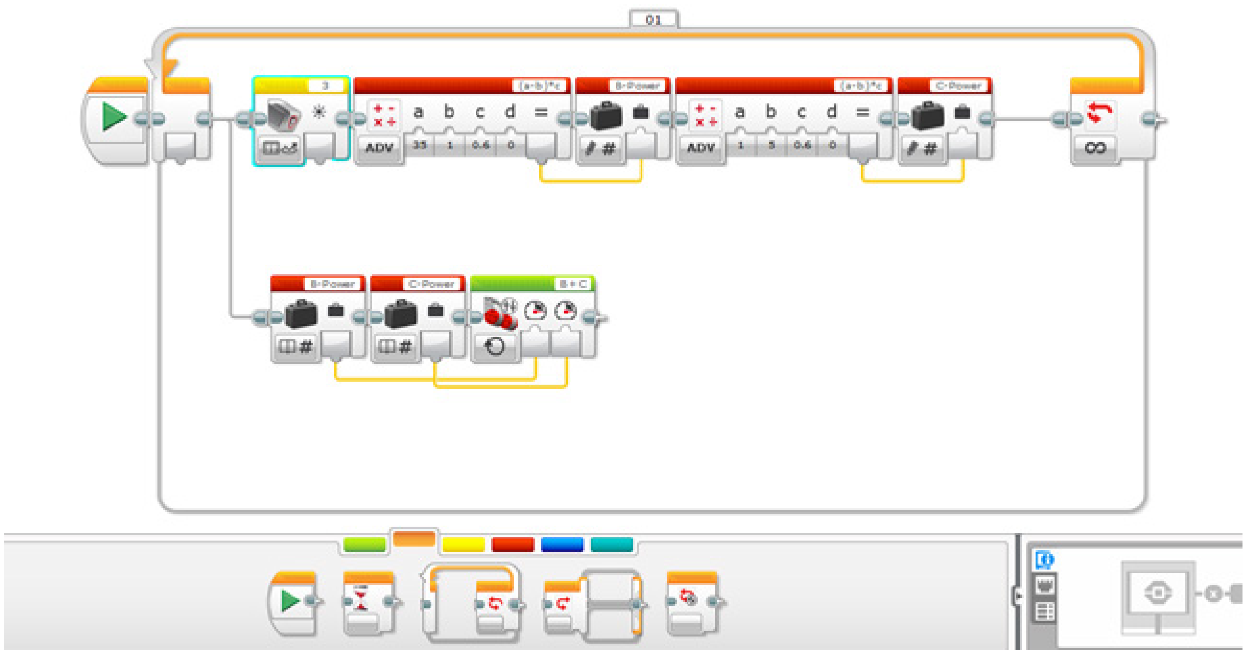
The data operation blocks let you write and read variables, compare values and much more. Please note: the red data blocks are only available in the programming software for PC/Mac and NOT in the EV3 Programmer App.

ADVANCED BLOCKS (Dark blue)

The advanced blocks let you manage files, Bluetooth connections and much more. Please note: the blue advanced blocks are only available in the programming software for PC/Mac and NOT in the EV3 Programmer

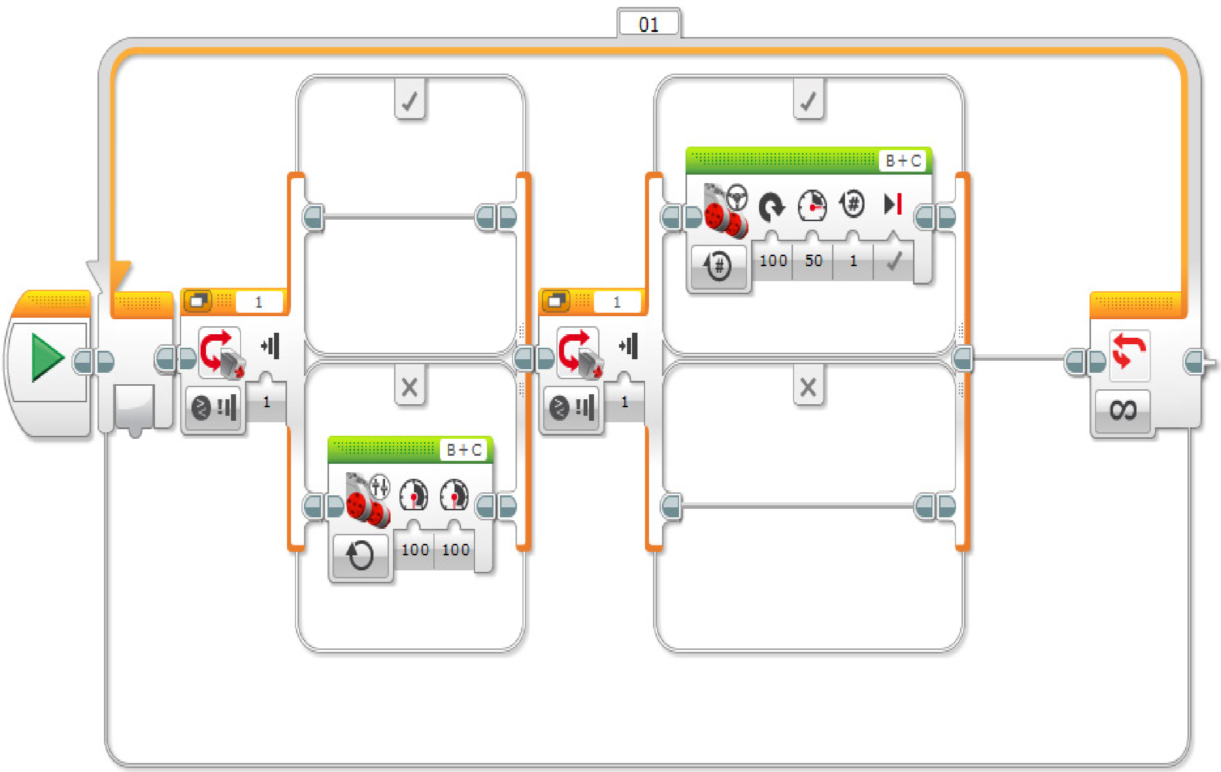
Appendix A.5 Line Follower Program

__Notes:__ In this program, everything is inside a loop. The color sensor is set to measure reflected light intensity; the math blocks are set to advanced; the upper variable blocks are set to write numeric (default); the lower variable blocks are set to read numeric; and the move tank block is set to on. On the formula spaces, the formula is (a-b)*c.



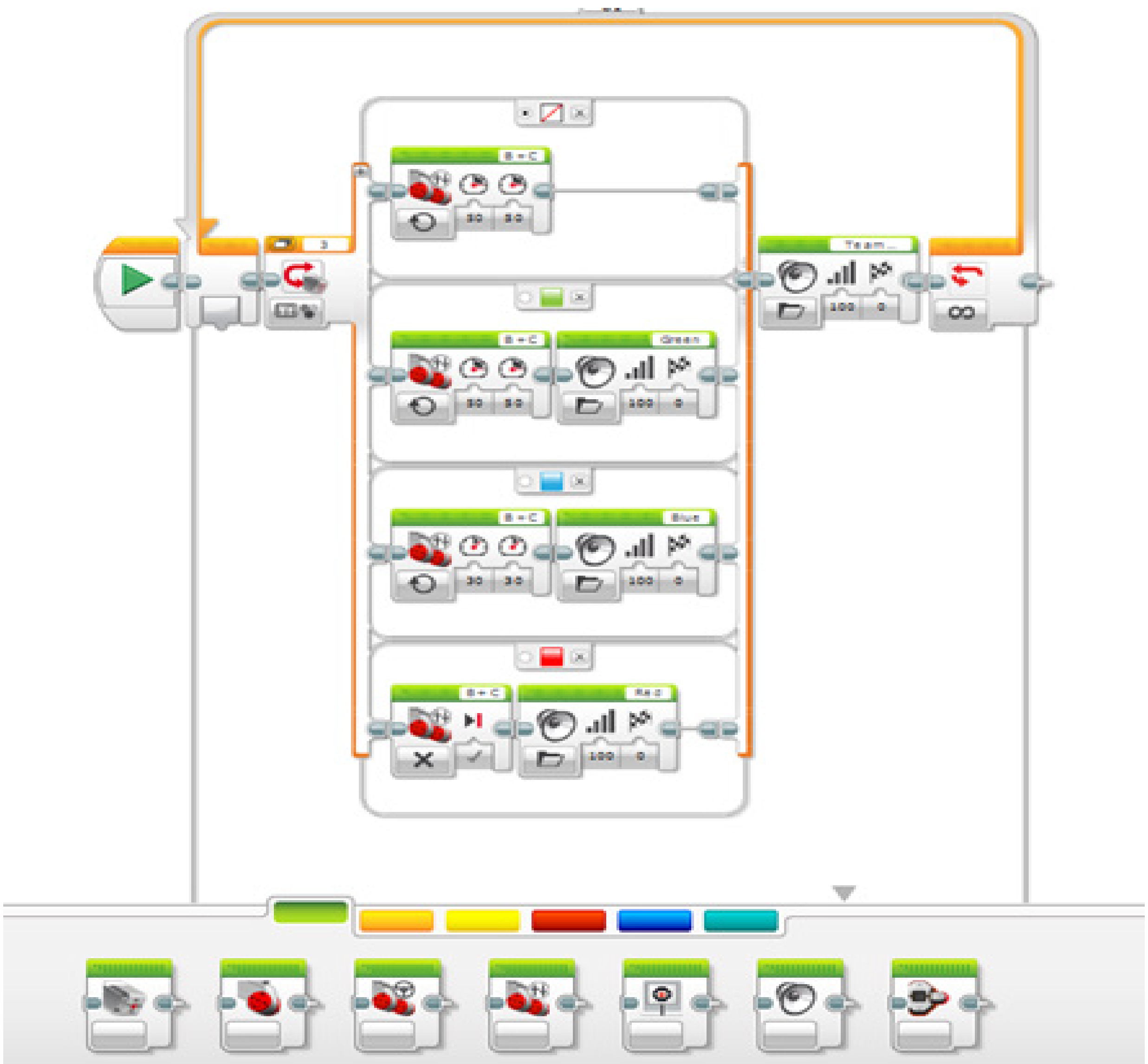
Appendix A.6 Bumper Car Program

The following program is an example of what students will be using on their LEGO® MINDSTORM® EV3 Bumper Car. Students will need to include a loop which will allow the car to run infinitely. This program allows the LEGO® MINDSTORM® EV3 model bumper car to travel until the touch sensor is activated by bumping into an object at which time it will reverse, turn, and follow a different path.



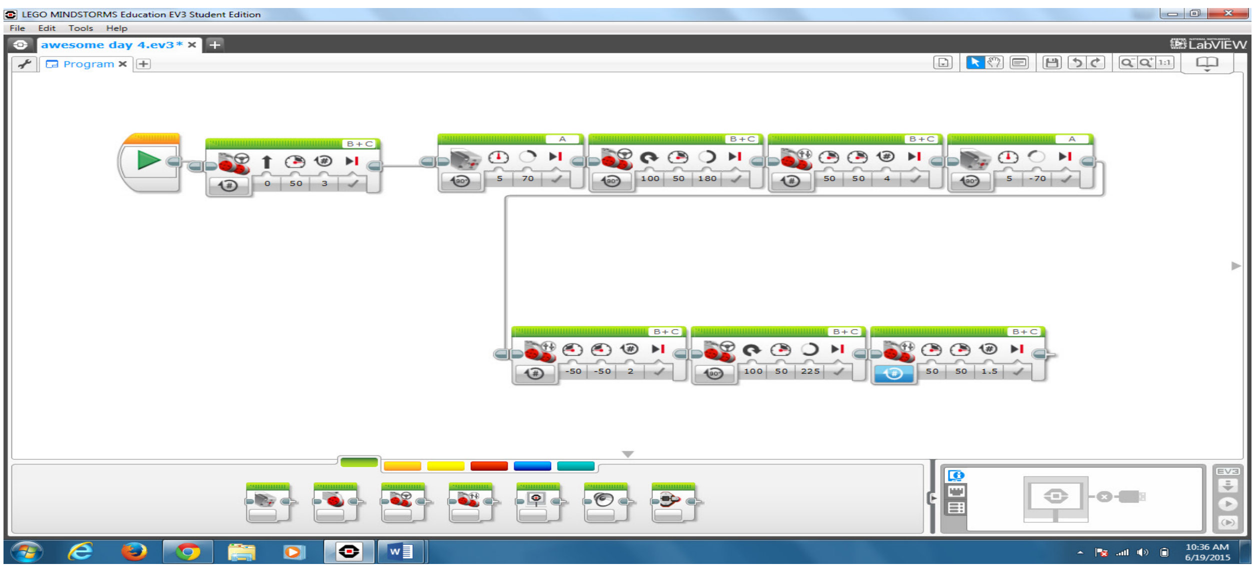
Appendix A.7 Color Sensor Program

Notes: The program is inside a loop. A switch block is dragged in and set to measure color with the color sensor. Then, the wanted actions are dragged to each color. At the top, the no color tab is selected as default, and the default action is selected. In this case, we set it to move both motors at 50% power.

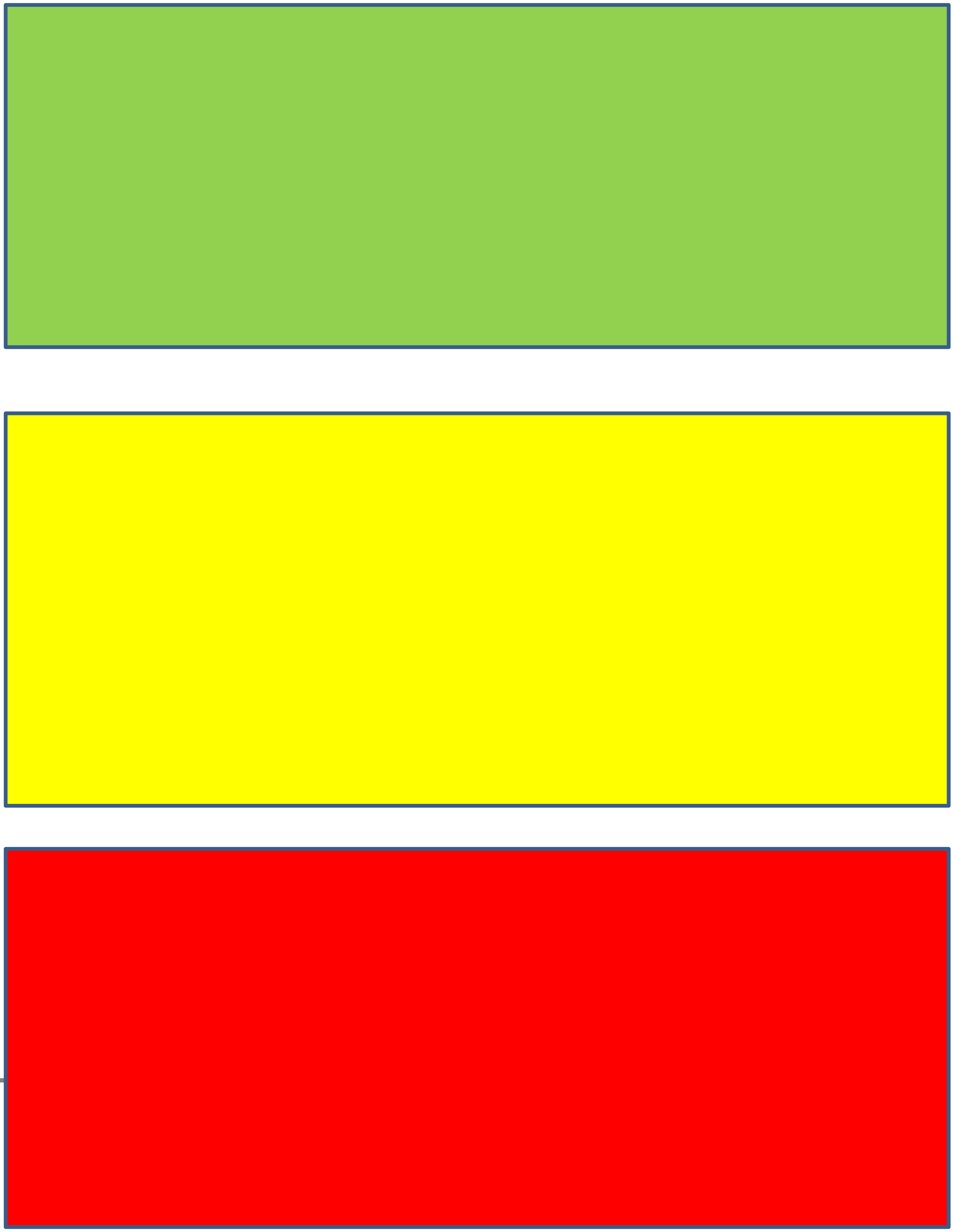


Appendix A.8 Basic Forklift Program

<u>Notes:</u> This program is completely open-ended. Any number of sensors can be used in conjunction with the forklifting action. This small and simple program illustrates the use of the medium motor block as the means to drive the lifting and lowering mechanism. This example also shows a claw mechanism driven by a worm or screw gear.



Appendix A.9 Colored Rectangles



Appendix A.10 Accident Investigation Report

Accident Investigation Report

1. Diameter of Wheel = _____________

2. Circumference = Diameter____________ × π = _____________

3. Speed = RPM____________ × Circumference____________ = ______________

4. v_i = ___________

5. v_f = ___________

6. $F = m\frac{(v_f - v_i)}{t}$ = ____________

Appendix A.11 Practice Problems for Newton's Second Law of Motion

Practice Problems for Newton's Second Law of Motion

You push an object, and it accelerates. You push harder on the same object, and it accelerates more quickly. Yet, when you push just as hard on a heavier object, it accelerates much more slowly. Why? It turns out that force, mass, and acceleration are related. The relationship is stated by Newton's second law of motion,

Force = Mass × Acceleration

or

$$F = m \cdot a$$

where F is the force, m is the mass, and a is the acceleration. The units are Newton's [N] for force, kilograms [kg] for mass, and meters per second squared [m/s^2] for acceleration. The other forms of the equation can be used to solve for mass or acceleration.

$$m = \frac{F}{a} \quad \text{and} \quad a = \frac{F}{m}$$

Example:

Engineers at the Johnson Space Center must determine the net force needed for a rocket to achieve an acceleration of 70 m/s^2. If the mass of the rocket is 45,000 kg, how much net force must the rocket develop?

Using Newton's second law, $F = m \cdot a$

$F = (45{,}000\ kg) \cdot (70\ m/s^2) = 3{,}150{,}000\ kg \cdot m/s^2$ or $F = 3{,}150{,}000\ N = 3{,}150\ kN$

Note that the units $kg \cdot m/s^2$ and Newton's are equivalent; that is, $1\ kg \cdot m/s^2 = 1\ N$

Also note that 1 kilo-Newton [kN] = 1000 Newtons [N]

Now, use Newton's second law to solve for force, mass, and acceleration. Give the equation used for each problem and show all work.

Problem 1: What net force is required to accelerate a car at a rate of 2 m/s^2 if the car has a mass of 3,000 kg?

F = __________

m =__________

a = __________

Problem 2: A 10 kg bowling ball would require what force to accelerate down an alleyway at a rate of 3 m/s^2?

F = __________

m =__________

a = __________

Problem 3: Sally has a car that accelerates at 5 m/s^2. If the car has a mass of 1000 kg, how much force does the car produce?

F = __________

m =__________

a = __________

Problem 4: What is the mass of a falling rock if it produces a force of 147 N?

F = __________

m =__________

a = __________

Problem 5: What is the mass of a truck if it produced a force of 14,000 N while accelerating at a rate of 5 m/s^2?

F = __________

m =__________

a = __________

Problem 6: What is the acceleration of a softball if it has a mass of 0.5 kg and hits the catcher's glove with a force of 25 N?

F = ___________

m =___________

a = ___________

Problem 7: Your own car has a mass of 2,000 kg. If your car produces a force of 5,000 N, how fast will it accelerate?

F = ___________

m =___________

a = ___________

Problem 8: Sally wants to accelerate even faster than in **Problem 3**, so she removes 500 kg of mass from her car. How fast will her 500 kg car accelerate if it produces 5,000 N of force?

F = ___________

m =___________

a = ___________

Problem 9: Sally challenges you to a race. On the first turn, you run off the course and your car strikes a large bale of hay. Your car still produces 5,000 N of force, but now it accelerates at only 2 m/s^2. What is the mass of your car now that the bale of hay is stuck to it?

F = ___________

m =___________

a = ___________

Problem 10: Even though she is way ahead of you, Sally switches her car to run on nitrous oxide fuel. The nitrous oxide allows her car to develop 10,000 N of force. What is Sally's acceleration if her car has a mass of 500 kg?

F = ___________

m =___________

a = ___________

Answer Sheet to Practice Problems for Newton's Second Law of Motion

Problem 1: What net force is required to accelerate a car at a rate of 2 m/s^2 if the car has a mass of 3,000 kg?

F = 6,000 N — *F* = 3,000 kg × 2 m/s^2 = 6,000 N

m = 3,000 kg

a = 2 m/s^2

Problem 2: A 10 kg bowling ball would require what force to accelerate down an alleyway at a rate of 3 m/s^2?

F = 30 N — *F* = 10 kg × 3 m/s^2 = 30 N

m = 10 kg

a = 3 m/s^2

Problem 3: Sally has a car that accelerates at 5 m/s^2. If the car has a mass of 1,000 kg, how much force does the car produce?

F = 5,000 N — *F* = 1000 kg × 5 m/s^2 = 5,000 N

m = 1,000 kg

a = 5 m/s^2

Problem 4: What is the mass of a falling rock if it produces a force of 147 N?

F = 147 N

m = 15 kg — *m* = 147 N / 9.81 N = 15 kg

a = 9.81 m/s^2

Problem 5: What is the mass of a truck if it produced a force of 14,000 N while accelerating at a rate of 5 m/s^2?

F = 14,000 N

m = 2,800 kg — *m* = 14,000 N / 5 m/s^2 = 2,800 kg

a = 5 m/s^2

Problem 6: What is the acceleration of a softball if it has a mass of 0.5 kg and hits the catcher's glove with a force of 25 N?

F = 25 N

m = 0.5 kg

a = 50 m/s^2 — *a* = 25 N / 0.5 kg = 50 m/s^2

Problem 7: Your own car has a mass of 2,000 kg. If your car produces a force of 5,000 N, how fast will it accelerate?

F = 5,000 N

m = 2,000 kg

a = 2.5 m/s^2 *a* = 5,000 N / 2,000 kg = 2.5 m/s^2

Problem 8: Sally wants to accelerate even faster than in **Problem 3**, so she removes 500 kg of mass from her car. How fast will her 500 kg car accelerate if it produces 5,000 N of force?

F = 5,000 N

m = 500 kg

a = 100 m/s^2 *a* = 5,000 N / 500 kg = 10 m/s^2

Problem 9: Sally challenges you to a race. On the first turn, you run off the course and your car strikes a large bale of hay. Your car still produces 5,000 N of force, but now it accelerates at only 2 m/s^2. What is the mass of your car now that the bale of hay is stuck to it?

F = 5,000 N

m = 2,500 kg m = 5,000 N / 2 m/s^2 = 2,500 kg

a = 2 m/s^2

Problem 10: Even though she is way ahead of you, Sally switches her car to run on nitrous oxide fuel. The nitrous oxide allows her car to develop 10,000 N of force. What is Sally's acceleration if her car has a mass of 500 kg?

F = 10,000 N

m = 500 kg

a = 20 m/s^2 a = 10,000 N / 500 kg = 20 m/s^2

Appendix A.12 Time to Deliver Table

Store	*Distance from Warehouse [in miles]	**Mass of Load [in tons]	Time to Deliver Goods
Mayberry	225	5.6	
Glen Oaks	161	12.2	
Park Place	121	2.1	
Newport	319	1.3	
Bentsen	593	7.7	

*Convert miles to inches, 1 mile = 1 inch.

**Convert tons to ounces, 1 ton = 1 ounce.

Appendix A.13 My Robot – Grading Rubric

Team #: ________

My Robot - Grading Rubric

	10	8	6	4	2	Points Earned (60 pts. Possible)
Difficulty Level of Assembly	Level V	Level IV	Level III	Level II	Level I	
Difficulty Level of Programming	Level V 17+ Blocks	Level IV 13-16 Blocks	Level III 9-12 Blocks	Level II 5-8 Blocks	Level I 1-4 Blocks	
Quality of Teamwork	All members helping and engaged during 5 random checks	All members helping and engaged during 4 random checks	All members helping and engaged during 3 random checks	All members helping and engaged during 2 random checks	All members helping and engaged during 1 random checks	
Completed Building on Time	Robot fully constructed by 4:30pm	1 step left	2 steps left	3 steps left	4+ steps left	
Completed Programming on Time	Program completed and running correctly by 4:30pm	Program completed but not running correctly by 4:30pm	1 block left in program	2 blocks left in program	3+ blocks left in program	
Behavior of team members	All members engaged and on task	1 infraction	2 infractions	3 infractions	4+ infractions	
					Total Points Earned	
					Bonus Points	
					Grand Total	

Appendix B. Video and Resource List

Day 1

Activity #1

Engage video: https://www.youtube.com/watch?v=cXgB3lIvPHI

Railway Safety Signs:

http://www.cnn.com/video/data/2.0/video/us/2014/04/03/lv-vo-train-slams-into-suv.cnn.html

Learn more about signs:

http://oli.org/education-resources/safety-tips/know-your-rails-signs-and-signals

Active signs:

http://oli.org/education-resources/safety-tips/know-your-rails-signs-and-signals

https://www.youtube.com/watch?v=cXgB3lIvPHI

Activity #2

Robot Educator:

https://www.youtube.com/watch?v=wvE5iXktVsY

Day 2

Activity #2

Robot Educator:

https://www.youtube.com/watch?v=wvE5iXktVsY

Basic Programming - LEGO® MINDSTORM® EV3 Programming Basics:

https://www.youtube.com/watch?v=CeCM_Z46Ys4

Using Touch Sensor - LEGO® MINDSTORM® EV3 Tutorial:

https://www.youtube.com/watch?v=YWOThIuvU4U

Day 3

Traffic Signs and their meanings:

https://www.youtube.com/watch?v=41dPJ322pK0

Using Color Sensor - LEGO® MINDSTORM® EV3 Programming 1.9 - How to follow a straight line smoothly:

https://www.youtube.com/watch?v=ODAGVeeDagk

Using Color Sensor- LEGO® MINDSTORM® EV3 Programming 1.3 - How to detect color (Using Color Sensor):
https://www.youtube.com/watch?v=xjOQ_LZRzw8

Day 4

Newton's Laws

1st Law:
https://www.youtube.com/watch?v=lbHt5mg_33w

2nd Law:
https://www.youtube.com/watch?v=qu_P4lbmV_I (NFL)
https://www.youtube.com/watch?v=iwP4heWDhvw
https://www.youtube.com/watch?v=nJTKiS444BQ

Day 5

This video can be used any day:
http://www.lego.com/en-us/mindstorms/videos