Final Report

to the

CENTER FOR MULTIMODAL SOLUTIONS FOR CONGESTION MITIGATION (CMS)

CMS Project Number: 2011-092142

CMS Project Title: LEGO Robot Vehicle Lesson Plans for Secondary Education – A Recruitment Tool

April 1, 2011 to March 31, 2012

from

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Date prepared August, 2012

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Acknowledgment of Sponsorship

This work was sponsored by a grant from the Center for Multimodal Solutions for Congestion Mitigation, a U.S. DOT Tier-1 grant-funded University Transportation Center.

LIST OF TABLES

ABSRACT

Robotics is a great way to get kids excited about science, technology, engineering, and math (STEM) topics. It is also highly effective in stimulating development of teamwork and self-confidence. This project provides transportation-related lesson plans for middle school-aged students utilizing LEGO® Mindstorms NXT robots to foster interest in the transportation engineering profession as a career choice.

A series of lesson plans for fifth through eighth graders was developed. The first lesson plan is a general introduction to engineering and transportation through the use of videos, slides and interactive discussions. The next four lessons are a hands-on guide exposing students to basic computer programming, mathematics as it relates to the tasks, and the robots as tools. The lesson plans' theme focuses on a significant area of the future of transportation—intelligent vehicles.

The objective is how an intelligent vehicle can help mitigate congestion through the use of sensors and computer programming. Participants program the intelligent vehicle to conduct activities to solve congestion issues on our roadways. Vehicle programming exercises include movement of the intelligent vehicle, following a route, emergency vehicle detection, pedestrian detection, travel distance calculations and travel time calculations.

During these lessons, students will learn some fundamentals of transportation engineering and how the use of advanced technology is integral to solving current and future transportation problems. They will also learn how much transportation affects the quality of life in our society. Students will hopefully become excited about the field of transportation and become interested in pursuing this field as a career.

In the piloting of the lesson plans, the course goal and objectives were met. Based on assessments at the end of each lesson and pre and post course questionnaires, students generally understood basic definitions and concepts presented. In general, students found learning about transportation engineering interesting and would like to take another LEGO robotics course. While the math component of the lessons was not a favorite, the students did not have difficulty understanding and computing the math problems.

The course goal of introducing students in grades 5-8 to transportation engineering as a potential career path using LEGO Robots as in intelligent vehicle was a success. Four course objectives were obtained.

1. What a transportation engineer does
2. What congestion and congestion mitigation is and the cause and effect relationships involved
3. What an intelligent vehicle can do and the basics of programming one
4. How to calculate travel distance and travel time of an intelligent vehicle for specific routes containing elements of congestion

EXECUTIVE SUMMARY

Congestion mitigation is much of the focus of the CMS theme, the USDOT Congestion Initiative, the FDOT SIS and the Florida Transportation Plan. The developed lesson plans educate, introduce, and demonstrate issues with congestion mitigation and provide discussion topics for instructors. The project exposes the next generation to three major areas of intelligent vehicles: traffic engineering, electrical/computer engineering and computer science. The lesson plans have been disseminated and will hopefully reach students of all ages and backgrounds.

As urban and rural areas continue to see traffic growth, the need for more transportation engineers is also increasing. The profession is losing over half of the state agency transportation engineers and many more local agency professionals as Baby Boomers retire. The *TRB Special Report 275—The Workforce Challenge* reviews some of the needs (1). This shortage has increased demand on universities to work harder at recruiting more and brighter students to the field.

A National Workforce Summit, sponsored by FHWA, Federal Transit Administration and Research and Special Programs Administration, was held in May 2002 to coordinate an initiative to preserve and advance the U.S. transportation system. The summit members outlined three critical areas that need to be addressed.

1. Ensuring that young people are attracted to the transportation jobs of the future;
2. Ensuring that workers are using the latest technologies and practices to improve transportation; and
3. Developing partnerships throughout the transportation and education communities to "institutionalize" transportation workforce development. (2)

This project addresses each of these three critical issues. According to Toole and Martin, "The next generation of transportation professionals is sitting in our classrooms today. It is not too early to consider what will affect their choices and how we need to support them in their development," (2).

Through the use of robots (3) and interesting projects laid out in the lesson plans, the secondary education students will be exposed to computers, basic computer programming, and mathematics, as it relates to the tasks, and robots as tools. During these lessons, students will learn some fundamentals of transportation engineering and how the use of advanced technology will be integral to solving current and future transportation problems. They will also learn how much transportation affects the quality of life in our society (4). Students will hopefully get excited about the field of transportation engineering and become interested in pursuing this field as a career.

While the majority of students found programming the robots to be the most memorable part of the lessons, students demonstrated knowledge gained, succeeded in calculation exercises and 11 of 13 students strongly agreed they would like to take another course.

CHAPTER 1 BACKGROUND

PROBLEM STATEMENT

As urban and rural areas continue to see traffic growth, the need for more transportation engineers is also increasing. The profession is losing over half of the state agency transportation engineers and many more local agency professionals as Baby Boomers retire. The *TRB Special Report 275—The Workforce Challenge* reviews some of the needs (*1*). This shortage has increased demand on universities to work harder at recruiting more and brighter students to the field.

A National Workforce Summit, sponsored by FHWA, Federal Transit Administration and Research and Special Programs Administration, was held in May 2002 to coordinate an initiative to preserve and advance the U.S. transportation system. The summit members outlined three critical areas that need to be addressed.

4. Ensuring that young people are attracted to the transportation jobs of the future;
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6. Developing partnerships throughout the transportation and education communities to "institutionalize" transportation workforce development. (*2*)

The project addresses each of these three critical issues. According to Toole and Martin, "The next generation of transportation professionals is sitting in our classrooms today. It is not too early to consider what will affect their choices and how we need to support them in their development," (*2*).

RESEARCH OBJECTIVES

The objective of this project is to develop transportation-related lesson plans for middle school-aged students utilizing LEGO® Mindstorms NXT robots (http://www.legoeducation.us/store) (5) to foster interest in the transportation engineering profession as a career choice.

Language in the lesson plans introduces the students, at their level, to the CMS research priority for recurrent congestion, describing the importance of modeling and assessment of advanced technologies and Intelligent Transportation Systems with respect to congestion mitigation; and improvements of traffic signal systems to reduce delays in urban corridors.

SCOPE OF STUDY

The project developed a series of lesson plans for fifth through eighth graders. Lessons are a hands-on guide for working with robots, computers, software and a transportation system.

CHAPTER 2 RESEARCH APPROACH

TASKS

1. Develop Outline of Lesson Plans

In the first few months, a detailed outline of the lesson plans was fully developed. The templates established by the USDOT, "Careers in Transportation Curriculum Project" (6), were used as a guide. It was decided, in order to focus on introducing students to transportation engineering, that the instructor would prebuild the LEGO robot vehicles prior to the first lesson.

Lesson Plan 1. What does a Transportation Engineer do?

Objectives
1. Define transportation engineering
2. Define congestion mitigation and travel time concepts
3. Identify examples of congestion mitigation
4. Describe possible components of an intelligent vehicle

Using a combination of a PowerPoint presentation and videos, students are introduced to engineering, transportation engineers and traffic congestion concepts, and intelligent vehicles. Many of the slides prompt the instructor for class discussions. Prior to starting the course, students take a pre course questionnaire. A lesson 1 assessment is administered focusing on mitigating traffic congestion.

Lesson Plan 2. LEGO Education Software Tutorials for an Intelligent Vehicle– Playing Sound, Use Display and Movement

Objectives
1. Construct basic software programs for intelligent vehicle
2. Run and test software programs constructed
3. Evaluate, refine, and solve programming problems, as necessary

Students learn how to use the education software developed by LEGO® to make their vehicle talk, show a screen display and move. The drag and drop block style of programming introduces students to the logic involved in computer programming. Students also learn that trial and error in testing and refining occurs often during programming.

Lesson Plan 3. Detect Emergency Vehicle and Calculate Travel Distance Exercise – Sound Sensor

Objectives

1. Program sound sensor on intelligent vehicle to mitigate congestion
2. Run and test intelligent vehicle programs constructed
3. Demonstrate travel distance calculations and programming
4. Evaluate, refine, and solve programming problems, as necessary

Students program their vehicle to use the sound sensor to pull over and stop for an emergency vehicle. They then program their vehicle to follow a bus route while calculating travel distance. Students must calculate the number of tire rotations to travel a defined distance for input parameters.

Lesson Plan 4. Follow a Route and Calculate Travel Time Exercise – Light Sensor

Objectives

1. Demonstrate travel time calculations
2. Calculate travel time of intelligent vehicle for given route
3. Program an intelligent vehicle for given route
4. Run and test intelligent vehicle route program
5. Evaluate, refine, and solve programming problems, as necessary

Students first learn to use the light sensor focused on the pavement. The first exercise has students detect and stop at an intersection stop bar. Students advance to programming the vehicle to follow a line using the light sensor. Students next learn how to calculate travel time and test their calculation by programming the vehicle.

Lesson Plan 5. Pedestrian and Vehicle Detection Exercise – Ultrasonic Sensor

Objectives

1. Program ultrasonic sensor on intelligent vehicle to mitigate congestion
2. Run and test intelligent vehicle programs constructed
3. Evaluate, refine, and solve programming problems, as necessary

The ultrasonic sensor is used to detect a pedestrian or other vehicle in the vehicles path. Students learn to program to stop for an object in the path and continue when the object is removed. Students are encouraged to design their own program utilizing all of the sensors and concepts learned.

2. Peer Review of Outline of Lesson Plans

The outline of lesson plans received a technical review. Review was provided by 6th/8th grade science teacher, Adrienne Thieke, and Nina Barker, Transportation Technology Transfer Center. Based on the technical review comments, the outline was finalized.

3. Construction of Transportation System Tabletop

In order to make the course as portable as possible and easy for others to adopt, it was determined that the concepts could be presented and conducted on the floor using black electrical tape. From observing anther LEGO robotic course, the original plan to have four students per laptop and robot was determined to be too many. Money saved by not purchasing tabletop supplies allowed for purchase of two additional robots.

4. Develop Teacher Guide and Student Workbook

Detailed Teacher Guide and Student Workbook were developed. The guide and workbook follow the USDOT, "Careers in Transportation Curriculum Project." The Teacher Guide can be found in Appendix A and Student Guide in Appendix B. The video files and programming file examples can be downloaded at http://cms.ce.ufl.edu/workforce_development/ (7).

5. Peer Review of Teacher Guide and Student Workbook

The Teacher Guide and Student Workbook went through a thorough review process by Adrienne Thieke, Nina Bark and Jaime Carreon.

6. Lesson Plan Pilot

The lessons were piloted in January and February 2012 to 6th and 7th grade Lyceum students at Lincoln Middle School. The Lyceum program at Lincoln Middle School is a highly competitive magnet program for academically-talented students. The program is designed to prepare students for International Baccalaureate (IB) and advanced placement high school programs. The students in the program are some of the best in Alachua County and ideal for recruitment. Students worked mostly in teams of two, with one team of three for a total of 13 students in the pilot.

7. Finalize and Distribute Lesson Plans

Adjustments to the lesson plans were made from observations and comments from student participation in the pilot. Lesson plans were finalized and posted to the Center for Multimodal Solutions for Congestion Mitigation website (http://cms.ce.ufl.edu/workforce_development/) for distribution. Notices were sent to LEGO Education, Florida public school teachers, ITE, USDOT, UF outreach coordinators, and more. The lesson plans have been downloaded 22 times by individuals or groups in 12 different states ranging from home school parents to university outreach programs.

An article was published in the May edition of the Florida Technology Transfer Quarterly http://www.t2ctt.ce.ufl.edu/t2ctt/Archive.asp (8). The project was featured as a showcase at the National Transportation Workforce Summit in Washington DC April 24-25, 2012. The lesson plan link will be added to the Careers in Transportation Curriculum Project webpage http://www.transportationcareers.org.

Table 2-1 summarizes tasks and deliverables.

Table 2-1. List of Deliverables

Task #	Description	Original Due Date	Date Delivered
1	Outline of Lesson Plans – draft to teacher	6/1/2011	6/4/2011
2	Peer Review of Outline of Lesson Plans	7/30/2011	7/20/2011
3	Black electrical tape on floor or white poster board instructions provided for robot course	9/30/2011	7/7/2011
4	Develop Teacher Guide and Student Workbook Lesson 1 - 5	12/31/2011	Lesson 2 7/14/2011 Lesson 1 9/14/2011 Lesson 3 10/31/11 Lesson 4 12/15/11 Lesson 5 12/23/12
5	Peer Review of Teacher Guide and Student Workbook Lesson 1 – 5	1/31/2012	Lesson 1 7/20/2011 Lesson 2 8/18/2011 Lesson 3 12/31/11 Lesson 4 1/13/12 Lesson 5 1/13/12
6	Lesson Plan Pilot	Dec/Jan/Feb2011/2012	Jan/Feb/March
7	Finalize and Distribute Lesson Plans	Feb/March 2012	March 2012

Chapter 3 Findings and Applications

In the piloting of the lesson plans, there were 13 students that participated (see Table 3-1.) Student number 5 decided not to take the course after initially signing up, there is no data for student number 5. The course goal of introducing students in grades 5-8 to Transportation Engineering as a potential career path using LEGO robots as an intelligent vehicle was met. All the students agreed or strongly agreed (see Table 3-2) that learning about transportation engineering was interesting. The majority of students gained knowledge of what a transportation engineer does and what traffic congestion is (Table 3-2).

Based on the pilot questionnaire (Table 3-3), 4 of the 13 students found the math component of the course to be their least favorite exercise. The assessment at the end of Lesson 4 is a travel time calculation based on the formula introduced and used to program their intelligent vehicle for a route. At first, several of the students were confused on how the assessment related to the lesson plan. The instructor explained that the same equation applied and the students all succeeded in calculating the travel time. While the math component of the lessons was not a favorite, the exercise demonstrated the need to connect math lessons to real world situations. To help motivate the students, a simple competition was developed to offer a prize to the first student with the correct answer. The exercise was enough to focus the students.

It was found that several of the 6th graders had difficulty following directions in the student guide while the 7th graders did not. Several 6th graders would attempt to program their intelligent vehicle without reading and following the directions. Some became frustrated until instructors pointed out where they were in the student guide and which steps to follow. Several of the 6th grade pairs began using the step-by-step instructions in the student guide while other pairs continued to try and figure the programming out on their own.

At the beginning of each weekly lesson, it took longer than expected to get everyone settled into their seats and the instructor to transition from the busy school day to providing a review discussion of the past lesson. For the final lesson plans document, a one page lesson review is provided to help facilitate future instructors in transitioning themselves and the students from the previous lesson to the next. Also, as students arrive independently, the lesson review will allow them to start thinking about the previous lesson plan and anticipating what is next prior to the beginning of the lesson.

Because of the small sample and lack of time to follow the interests of the students, collecting significant findings was not feasible at this time. However, based on assessments at the end of each lesson (see Appendix C) and pre-and post-course questionnaires, students generally understood basic definitions and concepts presented. In general, students found learning about transportation engineering interesting and would like to take another LEGO robotics course. Future studies will include grouping of similar responses and averaging of scores.

Table 3-1. Student Demography

Student #	Grade	Ethnicity	Sex
1	6th	Asian	Girl
2	6th	Asian	Girl
3	6th	Asian	Boy
4	6th	Asian	Girl
6	6th	White	Boy
7	6th	Asian	Boy
8	7th	African American	Boy
9	6th	White	Boy
10	7th	White/Asian	Girl
11	6th	Asian	Boy
12	6th	Asian	Boy
13	6th	Asian	Boy
14	6th	Asian	Boy

Tables 3-2. Pilot Pre and Post Questionnaire Results

	Student #1		Student #2		Student#3		Student #4		Student #6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. I like math.	3	3	5	5	5	5	5	5	3	3
2. I like science.	4	4	5	5	5	5	5	5	5	5
3. I can program a LEGO Mindstorm Robot.	2	5	5	5	2	4	1	5	5	4
4. I know what a transportation engineer does.	4	5	4	5	4	4	4	5	4	4
5. I understand what traffic congestion is.	4	5	5	5	4	5	5	5	3	5
6. I will consider going to college and becoming an engineer.	3	5	3	4	3	3	1	1	2	2
7. I will study hard at math and science.	5	4	5	5	5	5	4	5	4	5
8. Learning to program the robot by thinking logically will help me solve other problems.		5		5		4		4		3
9. The Lego Mindstorm Robot is easy to use.		5		5		4		4		5
10. The course helped me understand the use of math, science, and technology.		5		5		4		4		4
11. Learning about a transportation engineer was interesting.		4		5		4		5		4
12. I had enough time to complete the exercises.		5		5		5		5		5
13. The Lego robotics lessons were hard.		3		2		3		2		2
14. The Lego robotics lessons were fun.		5		5		4		5		4
15. I would like to take another robotics course.		5		5		5		3		5

1. Strongly Disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly Agree

Tables 3-2 Pilot Pre and Post Questionnaire Results continued

	Student #7		Student #8		Student #9		Student #10	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. I like math.	3	2	4	3	4	5	5	5
2. I like science.	3	3	5	5	4	4	5	5
3. I can program a LEGO Mindstorm Robot.	4	5	3	5	3	5	4	5
4. I know what a transportation engineer does.	3	4	5	4	4	4	3	5
5. I understand what traffic congestion is.	5	4	5	4	4	5	5	5
6. I will consider going to college and becoming an engineer.	3	3	5	4	5	4	3	4
7. I will study hard at math and science.	3	2	5	4	5	5	5	5
8. Learning to program the robot by thinking logically will help me solve other problems.		3		4		4		5
9. The Lego Mindstorm Robot is easy to use.		3		5		5		5
10. The course helped me understand the use of math, science, and technology.		4		5		4		5
11. Learning about a transportation engineer was interesting.		4		5		5		5
12. I had enough time to complete the exercises.		4		5		4		5
13. The Lego robotics lessons were hard.		2		2		5		4
14. The Lego robotics lessons were fun.		4		5		4		5
15. I would like to take another robotics course.		3		5		5		5

1. Strongly Disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly Agree

Tables 3-2 Pilot Pre and Post Questionnaire Results continued

	Student #11		Student #12		Student #13		Student #14	
	Pre	Post	Pre	Post r	Pre	Post	Pre	Post
1. I like math.	5	5	4	3	5	5	4	5
2. I like science.	5	5	5	4	4	4	5	5
3. I can program a LEGO Mindstorm Robot.	3	4	3	5	3	4	3	5
4. I know what a transportation engineer does.	4	5	3	4	3	4	4	5
5. I understand what traffic congestion is.	4	4	3	5	3	4	4	5
6. I will consider going to college and becoming an engineer.	5	5	3	3	3	3	3	4
7. I will study hard at math and science.	5	5	5	4	4	5	5	4
8. Learning to program the robot by thinking logically will help me solve other problems.		5		4		4		4
9. The Lego Mindstorm Robot is easy to use.		4		4		4		5
10. The course helped me understand the use of math, science, and technology.		4		4		4		4
11. Learning about a transportation engineer was interesting.		4				5		4
12. I had enough time to complete the exercises.		5		4		3		5
13. The Lego robotics lessons were hard.		1		3		4		2
14. The Lego robotics lessons were fun.		5		5		5		5
15. I would like to take another robotics course.		5		5		4		5

1. Strongly Disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly Agree

Table 3-3 Pilot Post Questionnaire Written Results

	Student #1	Student #2	Student #3	Student #4
What I will remember the most about this Introduction to Transportation Engineering Course is	when we learned how to use the sound sensor	how to program a Mindstorm robot	a lot of programming and trial and error	Programming it to say things, and display.
What is an engineer?	An engineer is a person who uses math, science and logic thinking to solve problems	An engineer is a person who builds something to help the world!	A person who utilize science, math and creativity into a product	A person who uses science and math to solve problems.
What would you like about being a transportation engineer?	I would like working with new technology to build and create.	Being a transportation engineer would be fun if I could program smart cars	the programming	Everything, mainly following line.
What would you NOT like about being a transportation engineer?	I would not like having to watch videos of car accidents to learn how to prevent them.	I would not like to be a transportation engineer because this job optimizes the traffic flow. I want to be a scientist which can discover things.	creating a program but using an unreasonable amount of time	Messing up!

Table 3-3 Pilot Post Questionnaire Written Results continued

	Student #6	Student #7	Student #8	Student #9
What I will remember the most about this Introduction to Transportation Engineering Course is	the testing of the robot.	trial and error	having fun with the robots while learning	the robot hitting the wall
What is an engineer?	A scientist that designs buildings, vehicles, etc and plans them.	a person who help mitigate congestion	a person that uses math and science to solve problems	Someone who implies math and science in their job.
What would you like about being a transportation engineer?	Helping make traffic easier for people	I will help people	solving problems	Being able to program expensive tools
What would you NOT like about being a transportation engineer?	The math and calculations	getting stuck	the algebra	finding out calculations

Table 3-3 Pilot Post Questionnaire Written Results continued

	Student #10	Student #11	Student #12	Student #13	Student #14
What I will remember the most about this Introduction to Transportation Engineering Course is	the fun process of programming my own robot and see it accomplish things	the robot kits	the robots	learning about how to prevent traffic	robot
What is an engineer?	Someone who uses math and science to help people's lives better and easier, not to mention safer!	someone who uses technology to help people.	A person who uses technology to help people.	An engineer is someone who designs and builds things depending what type of engineer you are.	A person who uses technology to make
What would you like about being a transportation engineer?	I could help save countless lives from the dangers of traffic and keeping myself from getting angry with traffic congestion	You get to work with technology!	You can create ways of transportation	What I would like about being a transportation engineer is operating with robots.	Being able to adding things to cars and using programming expensive tools
What would you NOT like about being a transportation engineer?	Umm.. Not really anything! I can't say anything bad other than the tons of work you put in. Some might not like it, but I do!	Some of the programs are kind of hard.	It's too complicated	What I would not like about being a transportation engineer is dealing with traffic congestion.	doing calculations

Chapter 4 Conclusions, Recommendations, and Suggested Research

Conclusions and Recommendations

A lesson review worksheet would be beneficial to help the students settle down as the instructor prepares to begin and while other students entered the classroom. Lesson reviews were added to the final Teacher Guide and Student Workbook. For the middle school age group, the assessments at the end of each lesson should be less open-ended. Adjustments were made to the assessments in the final Teacher Guide.

Since the 6th graders had more trouble following the step-by-step directions, it may be best for 5-6th grade students to follow along together as a group, while 7-8th grade students are mature enough to work independently.

During the months of March and April 2012, abbreviated versions of the lesson plans were also piloted with Girls Scout Troop 1520. The course is not complete at this time and data is not available. Ten, fourth grade girls are participating in the lesson plans.

The Technology Transfer Center will be offering the lesson plans to several afterschool programs in the fall of 2012. Lincoln Middle School, the location of the pilot, is interested in offering the course again. Due to the limited equipment, students that wanted to take the course were turned away. Howard Bishop Middle School as well as Lake Butler Middle School have voiced interest. The course is available for download to anyone for free. The dissemination plan was discussed in Chapter 2.

Suggested Research

Additional analyses of the pre-and post-questionnaire as well as the assessments could provide a starting point for developing a better measureable assessment plan. A larger sample size is needed to collect data and possibly reveal more significant findings.

The course could be expanded to include ‘Building your Intelligent Vehicle’, ‘Picking up and Delivering Cargo’, ‘Delivery Truck Plan a Route’, and a ‘Competition Module’. With the additional lessons, the course could run as a once-a-week after school program for a semester, or a 2-day summer camp.

Lesson plans could be simplified for a younger audience or made more complicated for high school students.

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Appendix A

Teacher Guide-Course Material

LEGO® Robot Vehicle Lesson Plans for Secondary Education – A Recruitment Tool for Transportation Engineering

Career Cluster Pathway:

- Mathematics: Engineering and Technology
- Transportation Systems/Infrastructure Planning, Management and Regulations

Recommended Grade Level – 5th to 8th Grade

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August 2012

Table of Contents

1. Acknowledgements

A. Business/Industry/Government Partner(s)

Lincoln Middle School
Girl Scout Troop 1520, Gateway Council

Acknowledgment of Sponsorship
This work was sponsored by a grant from the Center for Multimodal Solutions for Congestion Mitigation, a U.S. DOT Tier-1 grant-funded University Transportation Center.

B. **Others such as Educators** from Community College or University that provided assistance to module development.

Leslie Washburn, University of Florida Transportation Technology Transfer Center
Adrienne Thieke, Lincoln Middle School, Alachua County School District
Nina Barker, University of Florida Transportation Technology Transfer Center
Jaime Carreon, University of Florida Transportation Technology Transfer Center
Adela Beckerman, PhD and Leonard Fontana, PhD

2. Module Summary

A. Overview of Module

Robotics is a great way to get kids excited about science, technology, engineering, and math (STEM) topics. It is also highly effective in stimulating development of team-work and self-confidence. This project will present transportation-related Lesson plans for middle school-aged students utilizing LEGO® Mindstorms NXT robots to foster interest in the transportation engineering profession as a career choice.

Language in the Lesson plans will introduce the students, at their level, to the congestion mitigation solution research priority for recurrent congestion, describing the importance of modeling and assessment of advanced technologies and Intelligent Transportation Systems (ITS) with respect to congestion mitigation; and improvements of traffic signal systems to reduce delays in urban corridors.

Students will be exposed to computers, basic computer programming, mathematics as it relates to the tasks, and robots as tools. During these lessons, students will learn some fundamentals of transportation engineering and how the use of advanced technology is integral to solving current and future transportation problems. They will also learn how much transportation affects the quality of life in our society. Students will hopefully become excited about the field of transportation engineering and become interested in pursuing this field as a career.

B. Primary Career Cluster

Science, Technology, Engineering
Transportation Distribution and Logistics

C. Primary Career Pathway

Mathematics: Engineering and Technology
Transportation Systems/Infrastructure Planning, Management and Regulations

D. Related Occupations

Application Engineer, Automotive Engineer, Chemical Engineer, Civil Engineer, Computer Engineer, Computer Programmer, Industrial Engineer, Mechanical Engineer, Systems Engineer, Transportation Engineer

E. Recommended Subject Areas

Transportation Engineering, Computer Programming

F. Scenario Problem Statement

Traffic congestion has many negative effects on driver and passengers as they waste time with traffic delays. Delays result in loss in time at work, increase fuel costs, air pollution, stress and frustration, and negative impacts to emergency vehicle travel times.

The problem is how an intelligent vehicle can help mitigate congestion through the use of sensors and computer programming. Participants are to build, program and conduct activities using the intelligent vehicle to solve congestion issues on our roadways.

G. National Learning Standards	Florida Standards
8A SI 1.1-8	*SC.6.N.1.1-5*
8BPS2.1-3	*SC6.P.12.1*
8BPS 3.4	SC.7.N.1.1-5
8EST 1.1-5	SC.7.N.3.2
8EST2.1,3,4,5,6	SC8.N.1.1-6
8FSPSP3,2-3	SC.8.N.3.1
8FSPSP4.1-4	SC.8.N.4.1-2
8FSPSP5.3,5,6,7	8C.8.E.5.10
8GHNS1.1-2	
8GHNS2.1-3	

H. Course Goal

Introduce students in grades 5-8 to Transportation Engineering as a potential career path using LEGO Robots as an Intelligent Vehicle.

What I Want Students to Know	What I Want Students to be Able to Do
• What a transportation engineer does • What congestion and congestion mitigation is and the cause and effect relationships involved • What an intelligent vehicle can do and the basics of programming one • How to calculate travel distance and travel time of an intelligent vehicle for specific routes containing elements of congestion	• Define transportation engineering in their own words • Define congestion mitigation and travel time concepts • Identify examples of congestion mitigation • Describe possible components of an intelligent vehicle • Construct basic software programs for intelligent vehicle • Run and test intelligent vehicle software programs constructed • Demonstrate travel distance and travel time calculations • Calculate travel time of intelligent vehicle for given route • Program an intelligent vehicle for given route • Run and test intelligent vehicle route program • Evaluate, refine and solve programming problems, as necessary

Objectives

Course Objectives

1. Discuss in student's own terms what transportation engineering involves and give examples of congestion mitigation.
2. Describe several features of an intelligent vehicle and perform basic programming exercises.
3. Calculate travel distance and travel time of an intelligent vehicle for specific routes containing elements of congestion.

Session Objective

Lesson 1- What does a Transportation Engineer do?

1. Define transportation engineering
2. Define congestion mitigation and travel time concepts
3. Identify examples of congestion mitigation
4. Describe possible components of an intelligent vehicle

Lesson 2 – LEGO Education Software Tutorials for an Intelligent Vehicle

1. Construct basic software programs for intelligent vehicle
2. Run and test software programs constructed
3. Evaluate, refine and solve programming problems, as necessary

Lesson 3 – Detect Emergency Vehicle and Calculate Travel Distance Exercise

1. Program sound sensor on intelligent vehicle to mitigate congestion
2. Run and test intelligent vehicle programs constructed
3. Demonstrate travel distance calculations and programming
4. Evaluate, refine and solve programming problems, as necessary

Lesson 4 – Following a Route and Calculating Travel Time Exercise

1. Demonstrate travel time calculations
2. Calculate travel time of intelligent vehicle for given route
3. Program an intelligent vehicle for given route
4. Run and test intelligent vehicle route program
5. Evaluate, refine and solve programming problems, as necessary

Lesson 5 – Pedestrian and Vehicle Detection Exercise

1. Program ultrasonic sensor on intelligent vehicle to mitigate congestion
2. Run and test intelligent vehicle programs constructed
3. Evaluate, refine and solve programming problems, as necessary

I. Measurement Criteria

A pretest will be conducted in the first Lesson plan. A post test will be administered at the end of the last Lesson plan. Mini assessments will be given to students at the end of each day or lesson regarding the main idea of the activities. Teams may be awarded points for activities completed. Team with the most points awarded at the end of the course win the class competition.

J. Time required to complete Problem (Estimated):

- Lesson 1 – 1.5 hours
- Lesson 2 – 1.5 hours
- Lesson 3 – 1.5 hours
- Lesson 4 – 1.5 hours
- Lesson 5 – 1.5 hours

Total = 7.5 hours

K. Module Support Materials Summary

Introduction to Transportation Engineering PowerPoint
Laptop for every 2-3 students
LEGO Education Software for each laptop
Model Vehicle for every 2-3 students
LEGO Education Kit 9797 for every 2-3 students
Teacher Guide
Student Guide
¾ inch black electrical tape
Optional white poster board
Stop watch or timer

Video files

Video # 1 Design Your Future (4:12)
Video # 2 Erin Fletcher, a Civil Engineer (1:56)
Video # 3 Red Light Runner (0:15)
Video # 4 Intelligent Transportation Systems, Your Road to the Future (10:14)
Video # 4A Short Version Intelligent Transportation Systems, Your Road to the Future (2:50)
Video # 5 Ford Intelligent Vehicle Technology (2:47)
Video # 6 Move to the Right for Sirens and Lights (0:30)
Video # 7 Pull Over for Emergency Vehicle
Video # 8 School Bus Route
Video # 9 Kiva Robots (0:33)
Video # 10 The Dance of the Bots (1:24)
Video # 11 Volvo Pedestrian Detection (2:08)

Tutorial programming files

Lesson 2
1. Play Sound
2. Use Display
3. Drive Forward
4. Reverse
5. Accelerate
6. Curve Turn
7. Point Turn
8. Drive in Square
10. Parking Bay: Park-Display-Stop

Lesson 3
12. Detect Sound
Siren Pull Over
Bus Route

Lesson 4
16. Detect Dark Line
Follow a Line- travel time
17. Follow a Line

Lesson 5
14. Detect Distance
Detect Distance Extra
Pedestrian Detection

3. Module Teaching Materials

Lesson 1 Outline	***What does a Transportation Engineer do?***
Time Estimate: Day 1 - 1.5 hours	
Objectives	
1. Define transportation engineering 2. Define congestion mitigation and travel time concepts 3. Identify examples of congestion mitigation 4. Describe possible components of an intelligent vehicle	
Materials & Resources	
PowerPoint Presentation Laptop Videos # 1-4 Teacher Guide Pretest Questionnaire Mini Assessment 1 worksheet	

Agenda

Step	***Time***	***Activity***
1	15 min	*Complete the pretest questionnaire*
2	50 min	*Introduction to Transportation Engineering PowerPoint with embedded videos*
3	10 min	*Mini Assessment 1*
4	15 min	*LEGO Mindstorm NXT Intelligent Vehicle Demonstration*

Lesson 2 Outline	**LEGO Education Software Tutorials for an Intelligent Vehicle – Playing Sound, Use Display and Movement**

Time Estimate: 1.5 hours

Objectives

1. Construct basic software programs for intelligent vehicle
2. Run and test software programs constructed
3. Evaluate, refine and solve programming problems, as necessary

Materials & Resources

Laptop with LEGO Education Software
Video # 5 – Ford Intelligent Vehicle Technology
Pre-built LEGO NXT Intelligent Vehicle
Teacher programming example files
Cable to connect robot to computer USB laptop connection
Teacher Guide
Student Guide
Review Lesson 1 worksheet
Mini Assessment 2 worksheet

Agenda

Step	***Time***	***Activity***
1	10 min	*Review Lesson 1 Worksheet*
2	15 min	*Introduction to LEGO Education Software-Getting Started*
3	15 min	*Training Activities 1 and 2 - Play Sound and Using Display*
4	40 min	*Training Activities 3-8, 10- Making your Intelligent Vehicle Move*
5	10 min	*Mini Assessment 2*

Lesson 3 Outline	**Detect Emergency Vehicle and Calculate Travel Distance Exercise – Sound Sensor**
Time Estimate: 1.5 hours	
Objectives	
1. Program the sound sensor on the intelligent vehicle to mitigate congestion 2. Run and test intelligent vehicle programs constructed 3. Demonstrate travel distance calculations and programming 4. Evaluate, refine and solve programming problems, as necessary	
Materials & Resources	
Laptop with LEGO Education Software Video # 6-8 Pre-built LEGO NXT Intelligent Vehicle Cable to connect robot to computer USB laptop connection Teacher Guide Student Guide Teacher programming example files ¾ inch black electrical tape Optional white poster board Review Lesson 2 worksheet Mini Assessment 3 worksheet	

Agenda

Step	***Time***	***Activity***
1	10 min	*Review Lesson 2 Worksheet*
2	10 min	*Training Activity 12 – Detect Sound*
3	20 min	*Pull Over for an Emergency Vehicle*
4	40 min	*Follow a School Bus Route*
5	10 min.	*Mini Assessment 3*

Lesson 4 Outline	**Follow a Route and Calculate Travel Time Exercise – Light Sensor**
Time Estimate: 1.5 hours	
Objectives	

1. Demonstrate travel time calculations
2. Calculate travel time of intelligent vehicle for given route
3. Program an intelligent vehicle for given route
4. Run and test intelligent vehicle route program
5. Evaluate, refine and solve programming problems, as necessary

Materials & Resources

Laptop with LEGO Education Software
Pre-built LEGO NXT Intelligent Vehicle
Videos #9-10
Cable to connect robot to computer USB laptop connection
Teacher Guide
Student Guide
Teacher programming example files
¾ inch black electrical tape
Stop watch or timer
Review Lesson 3 worksheet
Mini Assessment 4 worksheet

Agenda

Step	***Minutes***	***Activity***
1	10 min	*Review Lesson 3 Worksheet*
2	15 min	*Training Activity 16 Detect Line – Stop at an Intersection Stop Bar*
3	25 min	*Training Activity 17 Follow a Line – Follow a Route*
4	15 min	*Calculate travel time*
5	15 min	*Calculate travel time for a route*
6	10 min	*Mini Assessment 4*

Lesson 5 Outline	**Pedestrian and Vehicle Detection Exercise – Ultrasonic Sensor**
Time Estimate: 1.5 hours	
Objectives	
1. Program ultrasonic sensor on intelligent vehicle to mitigate congestion 2. Run and test intelligent vehicle programs constructed 3. Evaluate, refine and solve programming problems, as necessary	
Materials & Resources	
Laptop with LEGO Education Software Pre-built LEGO NXT Intelligent Vehicle Video # 11 Cable to connect robot to computer USB laptop connection Teacher Guide Student Guide Teacher programming example files Review Lesson 4 worksheet Mini Assessment 5 worksheet Post Test Questionnaire	

Agenda

Step	***Minutes***	***Activity***
1	10 min	*Review Lesson 4 Worksheet*
2	20 min	*Training Activity 14 Detect Distance – Stop for a Pedestrian*
3	35 min	*Stop for a Pedestrian and then continue*
4	10 min	*Mini Assessment*
5	15 min.	*Post Test Questionnaire*

4. Assessment Materials

A. Final Evaluation Criteria

The pretest questionnaire focuses on vocabulary definitions, prior knowledge regarding engineering and transportation engineering and experience with robotics. The posttest questionnaire will demonstrate terms learned, and interest in engineering and transportation engineering.

Final Evaluation Scoring Guide

Scoring Sheet Lesson					
Student or Student Group Name:					
Mini Assessments	**Scoring**				
	1	2	3	4	5
1. Write down 2 examples of causes of traffic congestion. Write down 3 examples of negative effects of traffic congestion.					
2 What else would you want to program your intelligent vehicle to say or display that could reduce traffic congestions?					
3. How can an intelligent school bus reduce roadway congestion? How would an emergency vehicle detector improve roadway safety?					
4. Solve the travel time word problem.					
5. What other ways can an ultrasonic sensor prevent congestion on roadways?					
Total Score ____					

5. Appendix

A. Glossary of Terms

Glossary of Terms

Circumference – one wheel rotation or $\pi \times diameter$

Congestion Mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams

Distance traveled = circumference x wheel rotations

Engineer – person who applies science, math and creativity to solve problems

Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely

Traffic congestion – overcrowded or clogged roadways that prevent people and goods from moving efficiently

Transportation engineer – person who works to move people and goods safely and efficiently

Travel time – how long it takes to get from A to B

B. Other Items you choose to include

Teacher Guide
Student Guide

Appendix B

LEGO® Robot Vehicle Lesson Plans for Secondary Education – A Recruitment Tool for Transportation Engineering

Teacher Guide

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Teacher Guide

Lesson 1: What does a Transportation Engineer Do?

Objectives in this session

1. Define transportation engineering
2. Define congestion mitigation and travel time concepts
3. Identify examples of congestion mitigation
4. Describe possible components of an intelligent vehicle

What You Need

One set for entire class:

- Lesson 1 PowerPoint presentation
  - Videos #1 - Design Your Future (4:12)
  - Video # 2 – What does Engineering mean to you? (1.:25)
  - Video # 3 – Erin Fletcher, a Civil Engineer (1:56)
  - Video # 4 – Red Light Runner (0:15)
  - Video # 5 - Intelligent Transportation Systems, Your Road to the Future (10:14)
  - Shorter version of video #5A (2:50)

One for each student:

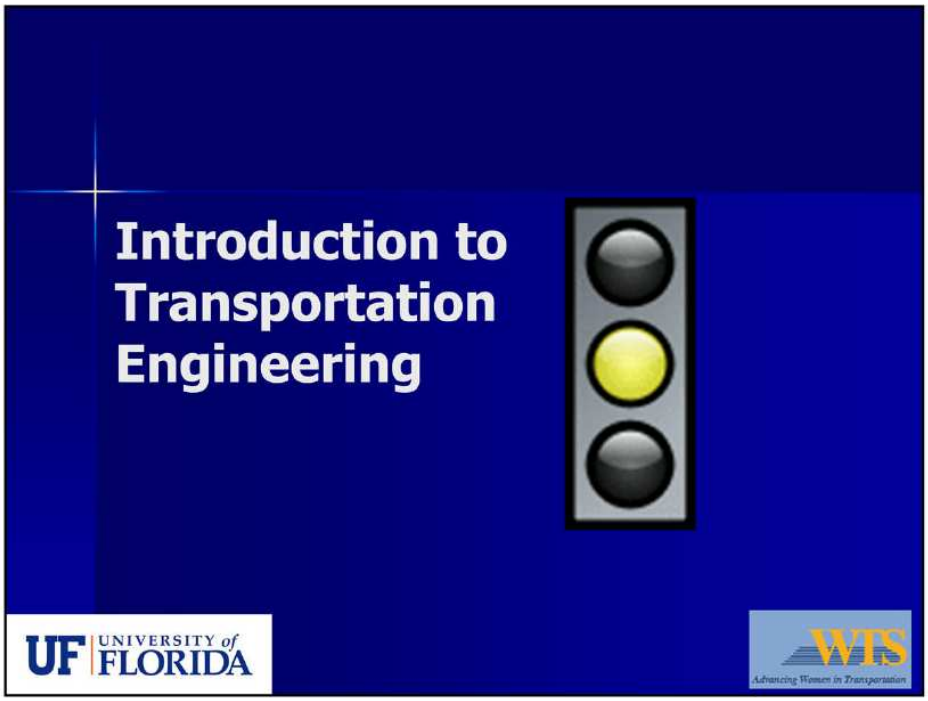
- Pretest
- Mini Assessment 1 worksheet

Agenda		
Step	***Time***	***Activity***
Day 1		
1	15 min.	*Complete the pretest*
2	50 min.	*Introduction to Transportation Engineering PowerPoint with embedded videos, slides*
3	10 min.	*Mini Assessment 1*
4	15 min	*LEGO Mindstorm NXT Intelligent Vehicle Demonstration*
Total	1.5 hrs	

Getting Ready

Assemble copies of worksheets for each student, a model vehicle for each group and the PowerPoint presentation for the class. Verify if videos are embedded in the PowerPoint or if they may need to be accessed via the internet, plan accordingly.

It is suggested that students not have the student guide for lesson 1 to avoid students looking ahead and finding answers to questions on the slides. Lesson 1 is provided in the student guide for reference in future lessons.



The organization of the instructor notes is summarized as follows:

Key Message: Slide title

Additional Info: Additional information the instructor should know, say, or do.

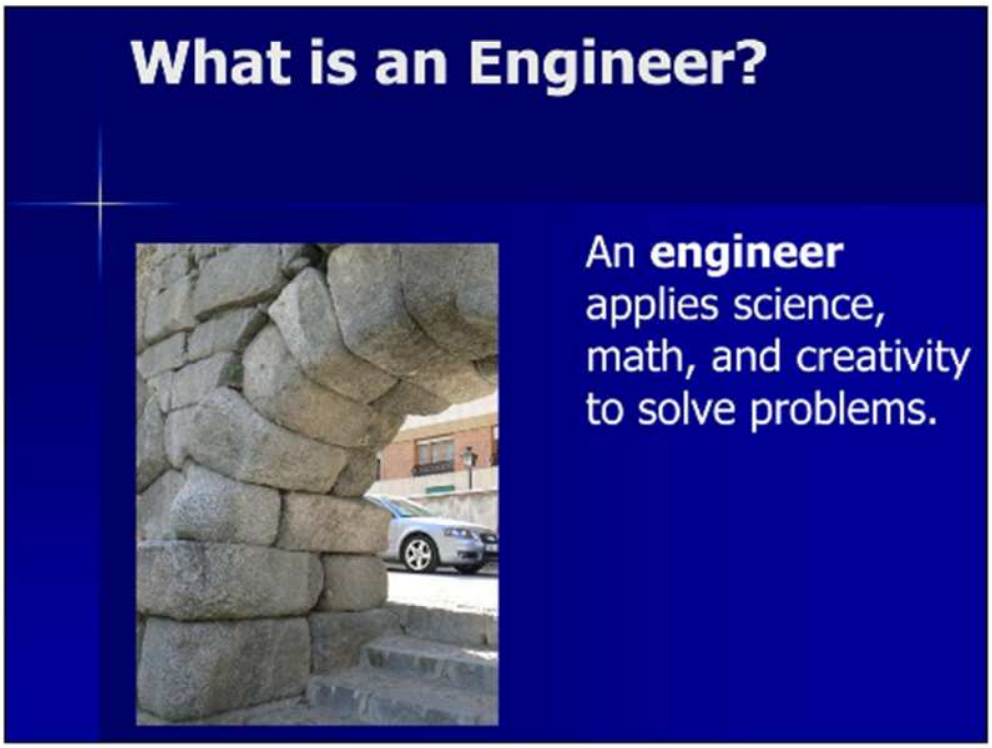
Questions/Interactivity: Any special supportive comments, cues to questions, or interactivity to stimulate conversation and check for session objective comprehension.

Possible Problems: Anything that might create a problem that the instructor should be prepared to forestall. Also, a place for the instructor to make any notes on problems not already addressed.

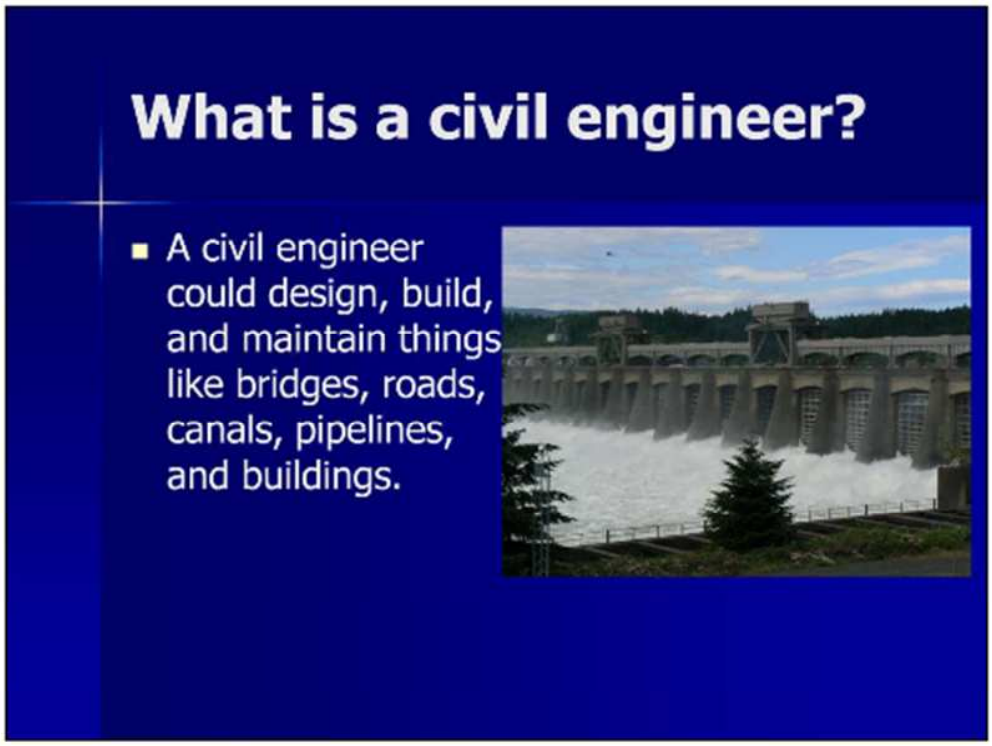
Slide Activity: The signal should change from red, yellow and green in slideshow mode. Source: http://commons.wikimedia.org/wiki/File:Traffic_light.gif

Key Message: Design Your Future – A Fun Job in Engineering

Possible Problems: Video file is imbedded in slide and will start by clicking on image. This only works if PowerPoint file and video file are in the same folder. Video file #1 is also included in the Lesson 1 file folder on the laptop desktop. The file can also be viewed at http://www.youtube.com/watch?v=Qnu12hl_XeE.

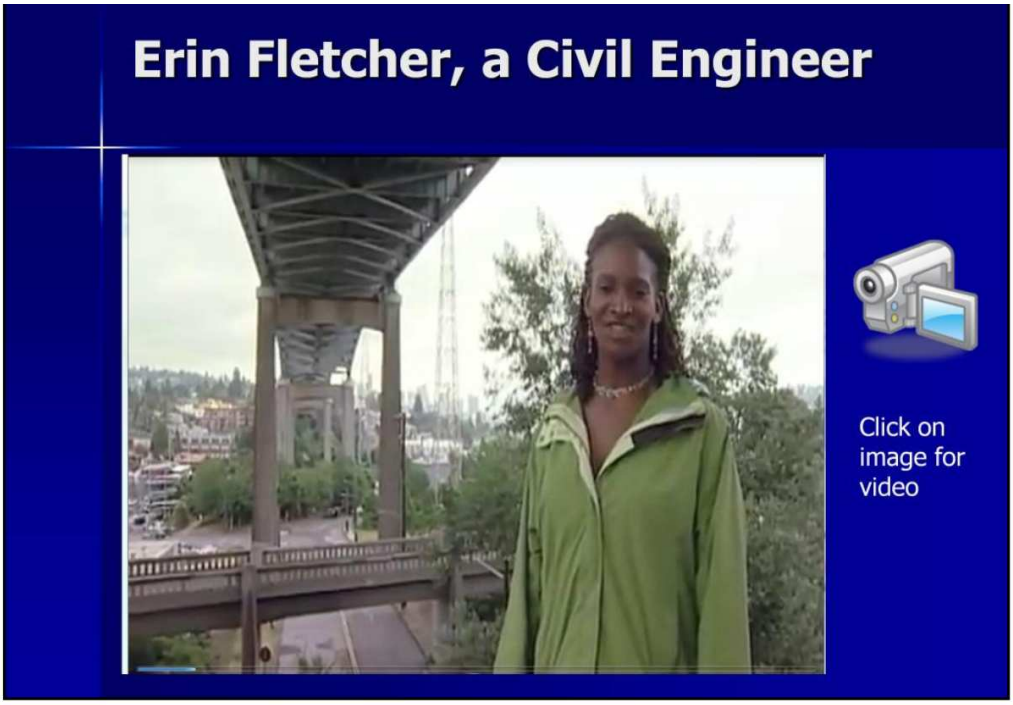


Key Message: What is an Engineer?



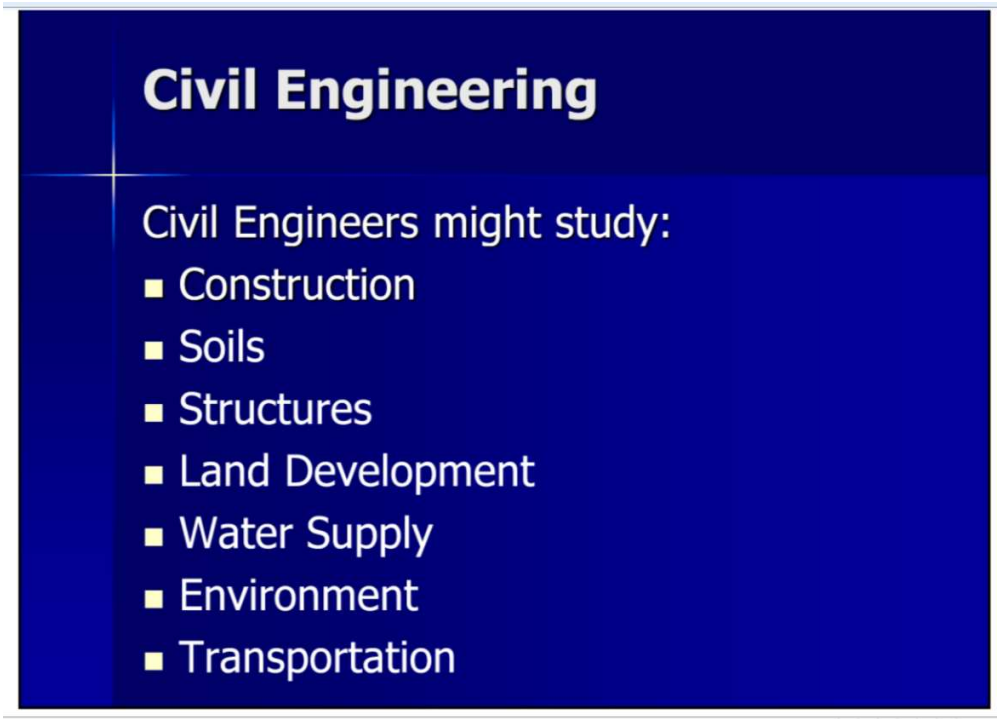
Key Message: What is a civil engineer?

Questions/Interactivity: Ask students to name a favorite bridge.



Key Message: Erin Fletcher, a Civil Engineer

Possible Problems: Video file is imbedded in slide and will start by clicking on image. This only works if PowerPoint file and video file are in the same folder. Video file#2 is also included in the Lesson 1 file folder on the laptop desktop. The file can also be viewed at http://www.youtube.com/watch?v=SuQitT8O4bI



Key Message: Civil Engineering

Additional Info: Questions/Interactivity: Instructor may have students try listing areas prior to advancing slide material. Intent is not to go into details of each area of civil engineering, but to get students to start thinking about engineering and their surroundings. If instructor is knowledgeable in the field, each area can be discussed in detail or advance to the next slide.

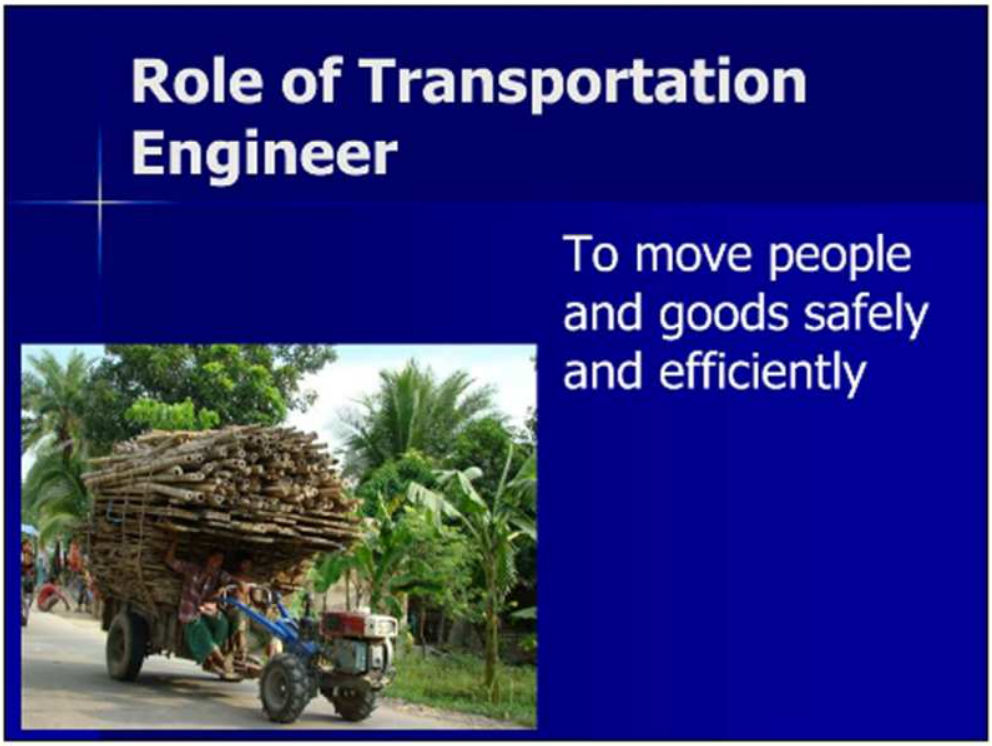
Key Message: Many Jobs of Civil Engineering

Additional Info: Photo Source: http://commons.wikimedia.org/wiki/File:Elbe_Water_Bridge.jpg

Questions/Interactivity: Get students to look at the photo and identify the different jobs that would be related to civil engineers. It might be necessary to write the list of professions on a board or flip chart so students could review as they examine the photo.

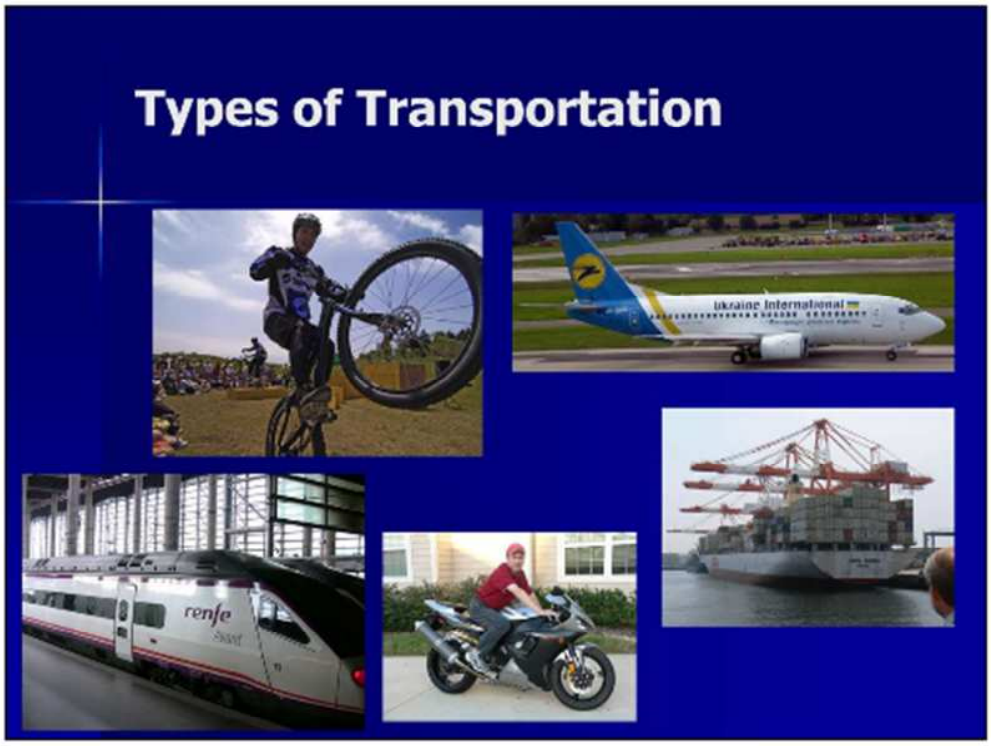
Construction engineer –challenges of dealing with construction over water, coordinating what is built first, and last
Soils engineer –design of towers holding up the bridge. How deep must the towers go down into the soil for proper support
Structural engineer –how far apart to place towers in order to support, water, bridges, and people
Land development –how much land will need to be purchased to construct and maintain the bridge, what kind of government permits will need to be obtained
Water engineer –how much water will the boats displace and raise the level of water in the canal
Environmental engineer –how to construct the towers in the water without disturbing the river bottom and endangering water quality
Transportation engineer –how to transport the boats and people across the bridge efficiently without long wait times

As a lead-in to the next slide, emphasize that transportation engineering is only one of many jobs that a person could choose in civil engineering.



Key Message: Role of Transportation Engineer

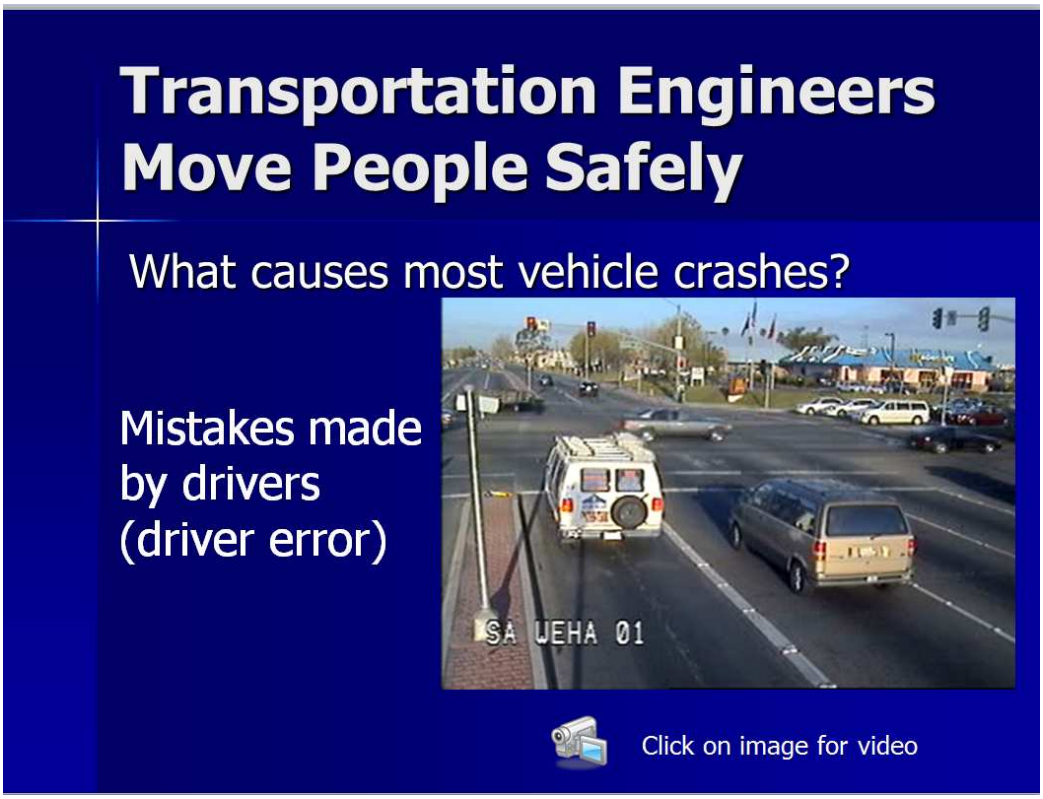
Additional Info: Photo Source:
http://commons.wikimedia.org/wiki/File:Transportation_Bangladesh_%283%29.JPG



Key Message: Types of Transportation

Additional Info: Photo Sources http://commons.wikimedia.org/wiki/File:Bicycle_trial.jpg http://commons.wikimedia.org/wiki/File:Ukraine_International_Airplane.jpg

Questions/Interactivity: Ask the students how many different types of transportation they can see in the photos. Did we miss any? Bus, car, RV, horse, moped, jet ski, truck



Key Message: Transportation Engineers Move People Safely

Additional Info: Click on photo for animation or watch Video #3, Red Light Runner

Possible Problems: Video file is imbedded in slide and will start by clicking on image. This only works if PowerPoint file and video file are in the same folder. Video file #3 is also included in the Lesson 1 file folder on the laptop desktop.

Key Message: Transportation Engineers Move People Efficiently

Additional Info: Discuss the definition of efficient –performing effectively with least waste of time, materials, and resources.

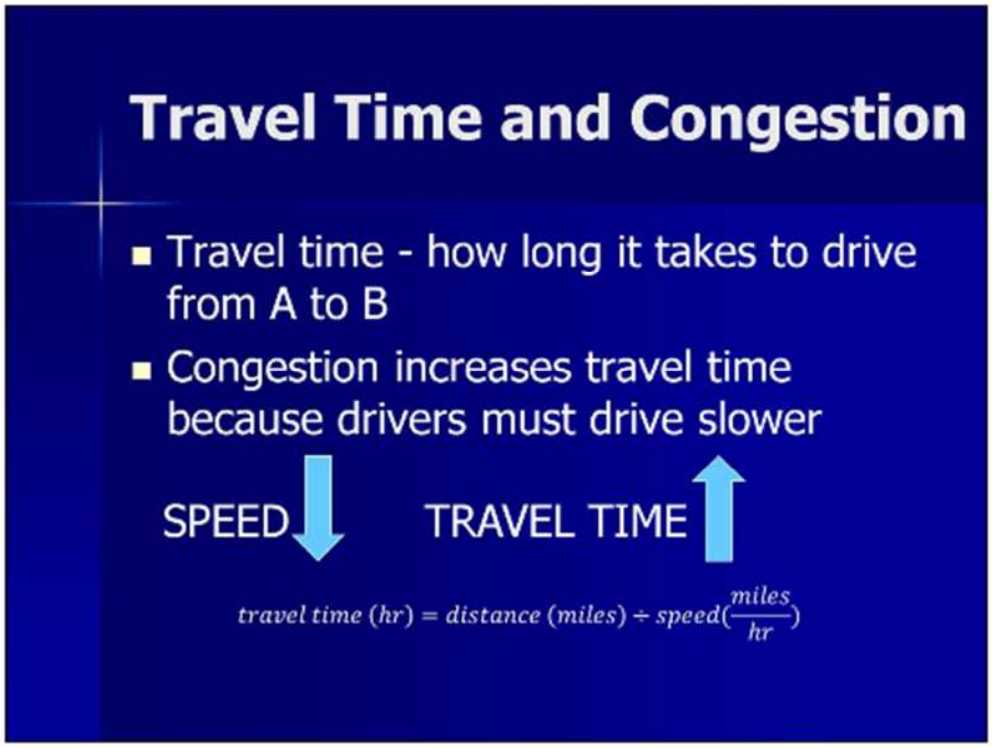
Key Message: Additional Info: Photo Source: http://commons.wikimedia.org/wiki/File:Lightning_Strike.jpg; www.freefoto.com

Questions/Interactivity: Ask for examples of bad weather that would cause congestion.

1. Fog
2. Snow
3. Too much rain
4. Hurricane
5. Tornado
6. Sleet

Key Message: Traffic Congestion Results

Additional Info: Photo Source: http://commons.wikimedia.org/wiki/File:Dhaka_traffic.jpg

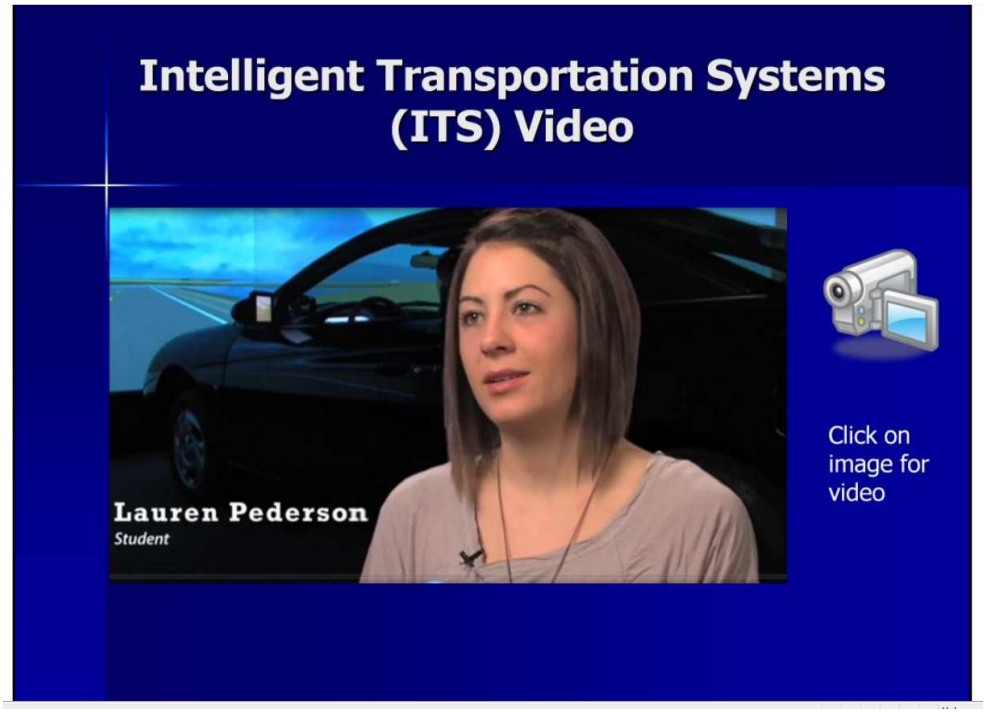


Key Message: Travel Time and Congestion

Key Message: Transportation Engineers Can Manage Congestion

Additional Info: Picture is a traffic management center in Madrid, Spain.

Key Message: Intelligent Transportation Systems (ITS)



Key Message: ITS Video

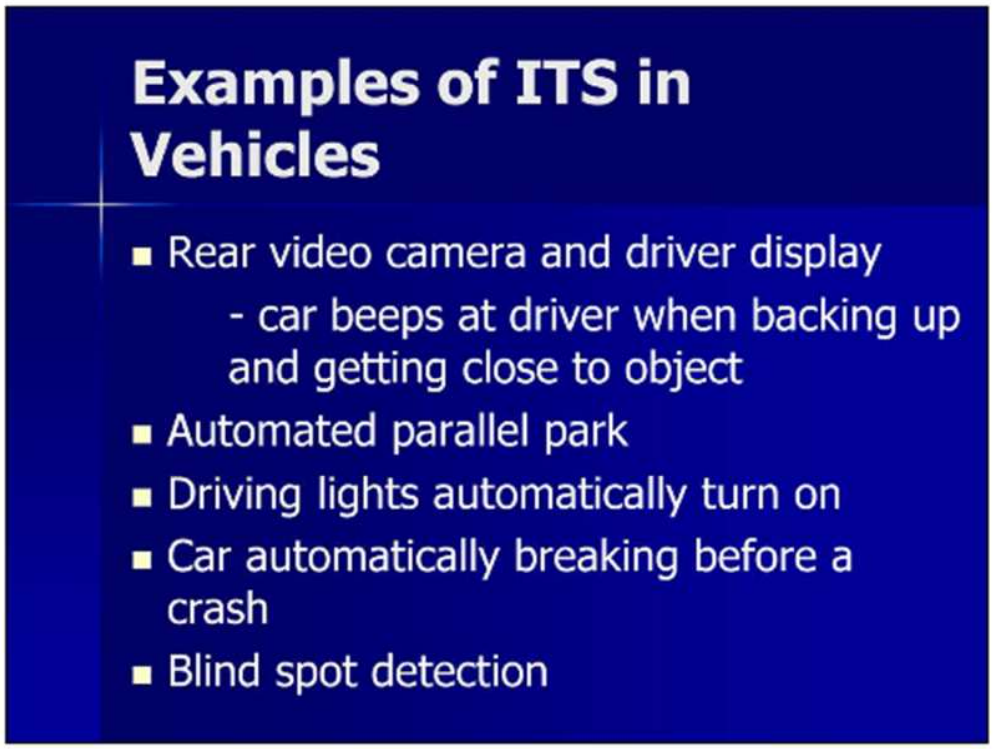
Possible Problems: Video file is imbedded in slide and will start by clicking on image. This only works if PowerPoint file and video file are in the same folder. Video file #4 is also included in the Lesson 1 file folder on the laptop desktop. The file can also be viewed at

Video #4Long Version http://www.youtube.com/watch?v=WcdoOUHBb9c

Video # 4A Short Version http://www.youtube.com/watch?v=XNBIRwyigGM&feature=player_embedded

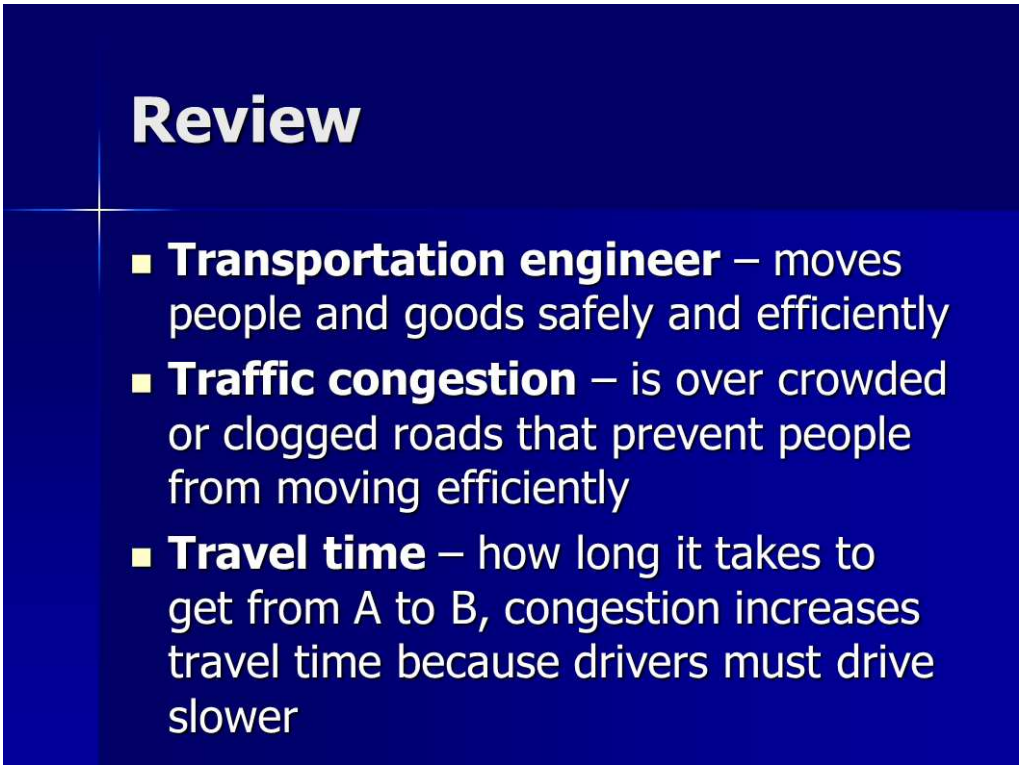
Key Message: Design Your Intelligent Vehicle

Questions/Interactivity: Discuss as a group, answers can include existing technology or future technology.



Key Message: Examples of ITS in Vehicles

Questions/Interactivity: Do they remember what ITS stands for?



Key Message: What did you learn?

Additional Info: Questions/Interactivity: After discussion, hand out mini assessment 1.

Teacher may choose to provide a demonstration of the LEGO Mindstorm Intelligent Vehicle at the end of Lesson Plan 1.

Possible Problems:

Teacher Guide

Lesson 2: LEGO Education Software Tutorials for an Intelligent Vehicle – Playing Sound, Use Display and Movement

Objectives in this session

1. Construct basic software programs for intelligent vehicle
2. Run and test software programs constructed
3. Evaluate, refine and solve programming problems, as necessary

What You Need

One for entire class:

- Example programming files located on laptop desktop
    01. Play Sound
    02. Use Display
    03. Drive Forward
    04. Reverse
    05. Accelerate
    06. Curve Turn
    07. Point Turn
    08. Drive in Square
    10. Parking Bay:
    Park- Display - Stop
- Videos #5 - Ford Intelligent Vehicle Technology

One for each robot group:

- Laptop with LEGO Education Software
- LEGO Education Kit 9797
- From the LEGO Education kit, pre-built robot vehicle
- From the LEGO Education kit, USB computer to robot cable
- Student Guide

One for each student

- Lesson 1 Review
- Mini Assessment 2

Agenda		
Step	***Time***	***Activity***
Day 2		
1	10 min	*Review Lesson 1 Worksheet*
2	15 min	*Introduction to LEGO Education Software-Getting Started*
3	15 min	*Training Activities 1 and 2 - Playing Sound and Using Display*
4	40 min	*Training Activities 3-8, 10- Making your Intelligent Vehicle Move*
5	10 min	*Mini Assessment 2*
Total	1.5 hrs	

Getting Ready

Build each of the LEGO robot vehicles ahead of time. Allow an hour to an hour and a half for each robot build. Make sure batteries are fully charged for robots and laptops. Building instructions are available in the Lego Education Software, on the laptop desktop and the booklet in the kit. (NOTE: For this course, the robots do not need the touch sensor and motor operated arm for striking a ball, so the last portion of the build should be skipped.) The other three sensors (light, ultrasonic and sound) will be installed but are not needed for Lesson 2 and will not be in the way.

Teachers should review the LEGO Mindstorm User Guide located on the laptop desktop prior to class.

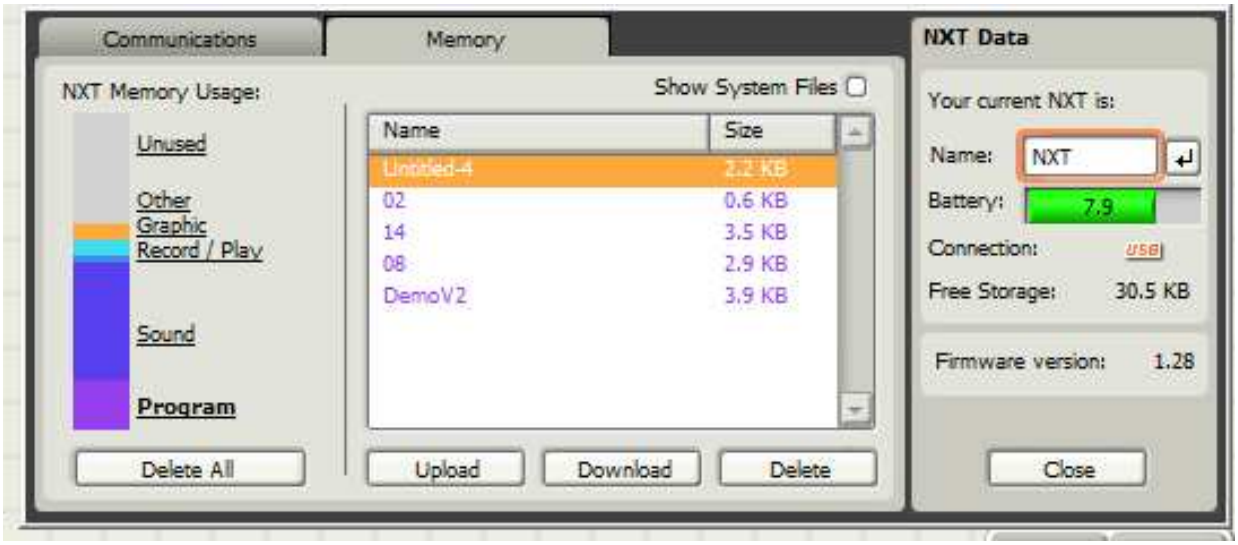
Number the laptops and robots prior to class, assign them to a student pair. For example, first student pair would have laptop number one and robot number one. If the students save files on either the laptop or robot, they will use the same equipment for each lesson.

Make sure the brick memory has space for the students to download their files.

Managing NXT Brick Memory

The NXT brick has a limited amount of memory. When the memory is full, click on the "NXT Window Button" (upper left hand corner of the controller) to manage files. The NXT Brick must be on and connected to the computer.

Controller



Step 1. Review Lesson 1

Hand out Review Lesson 1 Worksheet as students enter the classroom. Worksheets are located at the end of this document.

Definition Review

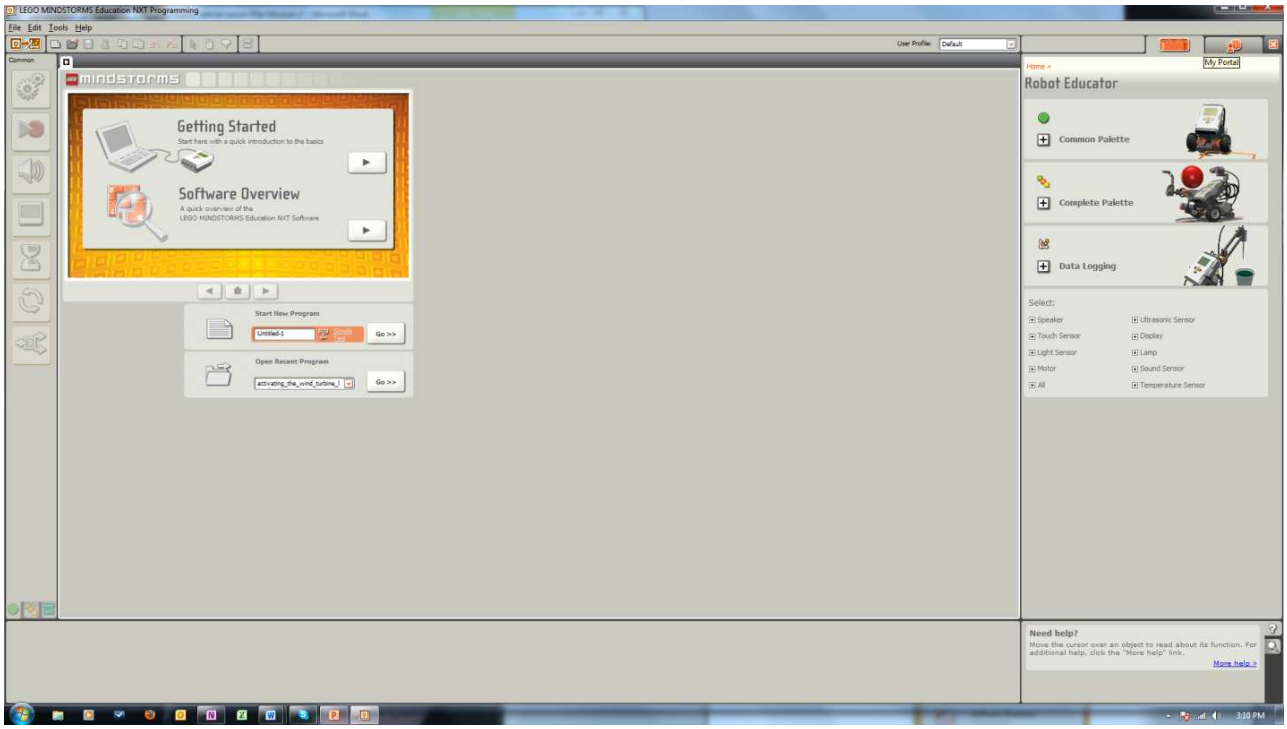
Congestion mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely
Traffic congestion - overcrowded or clogged roadways that prevent people and goods from moving efficiently
Transportation engineer – person who works to move people and goods safely and efficiently
Travel time – how long it takes to get from A to B

For review of an intelligent transportation system, the entire class may either watch the following video online from the following link or each group may view it on their laptop from the desktop in Lesson 2 folder.

Video #5 - Ford Intelligent Vehicle Technology
http://www.youtube.com/watch?v=TFfy_LNyt-Y

Step 2. Introduction to LEGO Education Software

Open the LEGO Education Software program, NXT 2.1 Programming.



Getting Started

Teacher and students should watch both the "Getting Started" and "Software Overview" clips by clicking on the arrow to the right of each. You will need to continue to click on the arrow button when prompted to finish the video. This can be done either individually or on overhead screen as a class.

To turn on the NXT brick or select "ON" option on the screen, press the orange button. To turn the brick off, press the gray rectangular button below the orange button and hold. The gray arrows are for scrolling through selections.

Step 3. Training Activities 01. Play Sounds and 02. Using Display

Now students will begin programming their intelligent vehicle.

An intelligent vehicle will need to communicate with the passengers riding in the vehicle. The first activity students will learn is to program the vehicle to say "Stop". Students will then program the vehicle to show "Stop" on the dashboard.

Each training activity will have a Challenge Brief, Building Guide, and Programming Guide. The Challenge Brief will demonstrate the activity; the Building Guide is not needed since we are using pre-assembled intelligent vehicles; the Programming Guide will guide you through the programming activity.

Training Activity 01. Play Sound

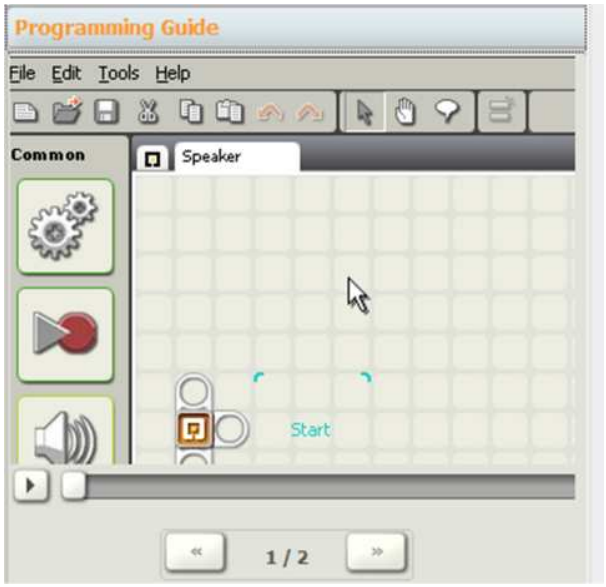
A. Begin by starting new program file by clicking "GO" in the "Start New Program" area.

B. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

C. Click on Activity 01. Play Sound

D. By default, the Challenge Brief will be shown. Click on the Play Button to view the activity.

E. Click the "Programming Guide" bar (you may need to use the scroll bar on the far right to find it) and watch the tutorial that shows how to drag the desired icon(s) into the proper window.



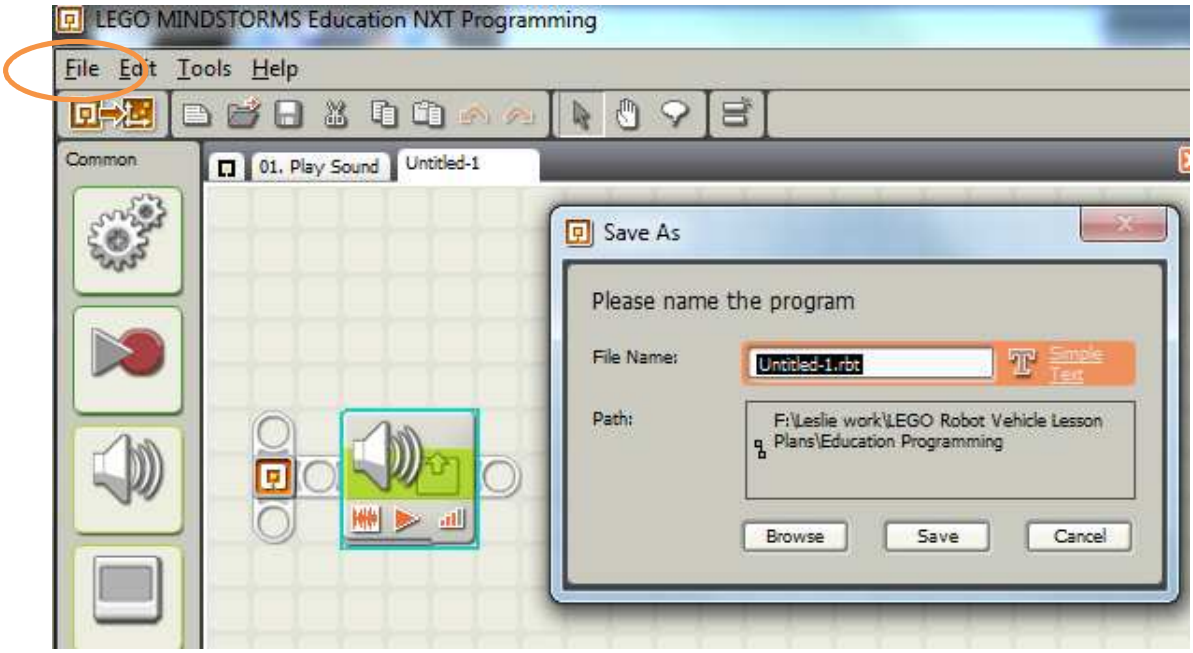
F. Complete the program as illustrated, but instead of selecting the "Error" file from the configuration panel, select the "Stop" file.

Configuration Panel

G. Connect the USB cable to the computer and the intelligent vehicle. Download and run the program by clicking the "Play" button in the center of the controller.

H. Did your intelligent vehicle say "Stop"?

I. To save your programming file to use again, click "File Save", name the file and find the location to save files using the browse button. Teachers may want to pre-determine a naming convention and location for students to save files.

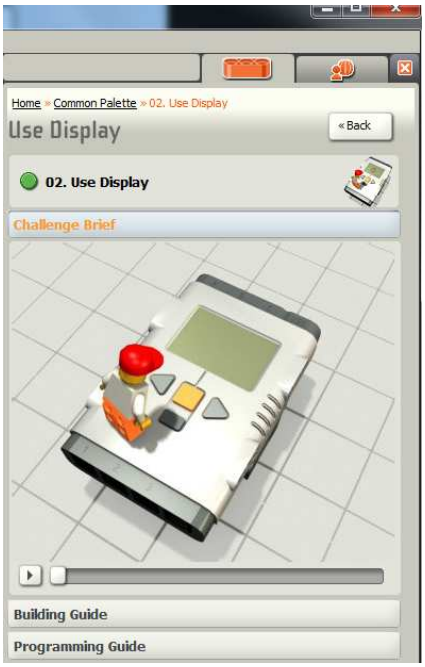


To return to the Common Palette, click the "Back" button in the upper right hand corner of your window.

Training Activity 02. Use Display

A. Open a new programming file.

B. Click on Activity 02. Use Display in the Common Palette



C. Click on the "Programming Guide" bar and recreate the program from the guide (use the left and right arrow buttons to navigate). Instead of selecting "LEGO Minifig Head" from the configuration panel, select "Stop".

D. Connect the USB cable to the computer and the intelligent vehicle.

E. Download and run the program by clicking the "Play" button on the controller.

Did your intelligent vehicle screen or dashboard show a "Stop" sign?

To save your programming file to use again, click "File -> Save", name the file and find the location to save files using the browse button.

Step 4. Training Activities 3-10 Making your Intelligent Vehicle Move

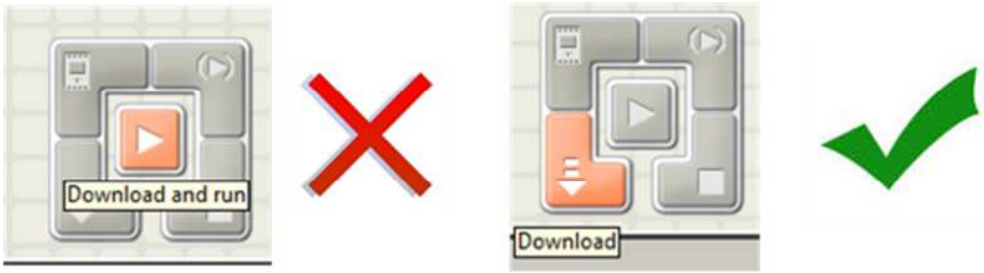
Training Activity 03. Drive Forward

A. Open a new programming file.

B. Click on Activity 03. Drive Forward in the common palette.

C. Click on the "Programming Guide" bar and recreate the program from the guide (use the left and right arrow buttons to navigate).

> This time instead of download and run, download the program to the intelligent vehicle. Since the vehicle will be moving, it is best to download the program, disconnect the vehicle from the computer, place on the floor, and run the program from the vehicle.
>
> You do not want the vehicles rolling off of the tables.



D. Connect the USB cable to the computer and the intelligent vehicle.

E. Download the program to the intelligent vehicle.

F. Disconnect the USB cable from the vehicle.

G. Place the vehicle on the floor.

H. Press the orange button on the NXT brick once to select "My Files" and again to select "Software Files".

I. Use the left and right arrow keys to find your file (the last file you downloaded to the NXT brick will appear first on the screen).

J. Press the orange button to select the file and again to run the file.

MAKE SURE YOUR VEHICLE IS ON THE FLOOR PRIOR TO RUNNING THE FILE!

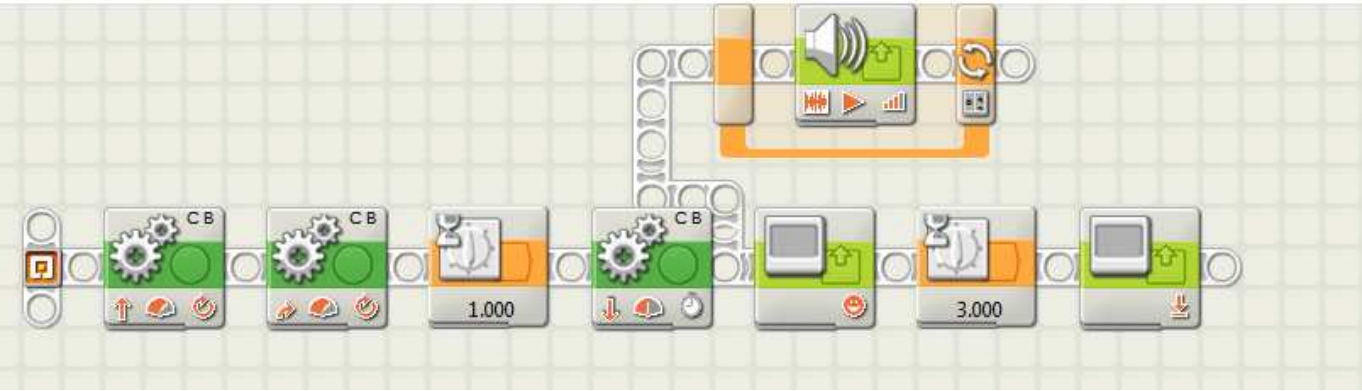
K. Continue with common palette activities 4 through 8 and 10 ("Reverse", "Accelerate", "Curve Turn", "Point Turn", "Drive in Square", and "Parking Bay"). **Skip Activity 9. My Block.**

L. Once you have completed training activities 1-8 and 10 you have completed Lesson 2 and are ready for the mini assessment.

Additional Challenge 1 - Program to "Park", "Display", and say "Stop" Using Display

Now that you have mastered how to make your intelligent vehicle move, program your vehicle to *"Park", "Display"* and *say "Stop".*

Example program, see Park-Display-Stop.rbt for details of each block.



Additional Challenge 2

What else can you program your intelligent vehicle to say or display that could reduce traffic congestion? Program and run, be prepared to explain how your program reduces traffic congestion.

Step 5.Mini Assessment 2

Hand out mini assessment 2 for the students to complete.

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Teacher Guide

Lesson 3: Detect Emergency Vehicle and Calculate Travel Distance Exercise – Sound Sensor

Objectives in this session

1. Program the sound sensor on the intelligent vehicle to mitigate congestion
2. Run and test intelligent vehicle programs constructed
3. Demonstrate travel distance calculations and programming
4. Evaluate, refine and solve programming problems, as necessary

What You Need

One set for entire class:

- Example programming files located on laptop desktop
  12. Detect Sound
  Bus Route
  Siren Pull Over
- Videos # - 6. Move to the Right for Sirens and Lights
  7. Pull Over for Emergency Vehicle
  8. School Bus Route
- ¾ inch black electrical tape
- Optional white poster board

One for each robot group:

- Laptop with LEGO Education Software
- LEGO Education Kit 9797
- From the LEGO Education kit, pre-built robot vehicle and USB cable
- Student Guide

One for each student

- Lesson 2 Review
- Mini Assessment 3

Agenda		
Step	***Time***	***Activity***
1	10 min	*Review Lesson 2*
2	10 min	*Training Activities 12 – Detect Sound*
3	20 min	*Pull over for an Emergency Vehicle*
4	40 min	*Follow a School Bus Route*
5	10 min.	*Mini Assessment 3*
Total	1.5 hrs	

Getting Ready

Using the pre-built LEGO robot vehicles, make sure batteries are fully charged for robots and laptops. Teachers should review the LEGO Mindstorm User Guide located on the laptop desktop prior to class.

Teachers may want to pre-determine a naming convention and location for students to save files.

The school bus route for step 4 should be taped out on the floor or on a piece of white poster board prior to class. Use black electrical tape. The route is a 15 inch wide and 24 inch long rectangle for this Lesson plan.

Step 1. Review Lesson 2

A. Hand out Review Lesson 2 Worksheet as students enter the classroom. Worksheets are located at the end of this document.

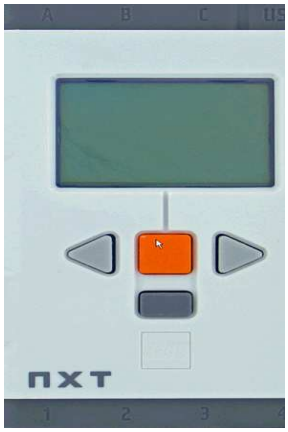
Definition Review

Congestion mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely
Traffic congestion - overcrowded or clogged roadways that prevent people from moving efficiently
Transportation engineer – person who works to move people and goods safely and efficiently
Travel time – how long it takes to get from A to B

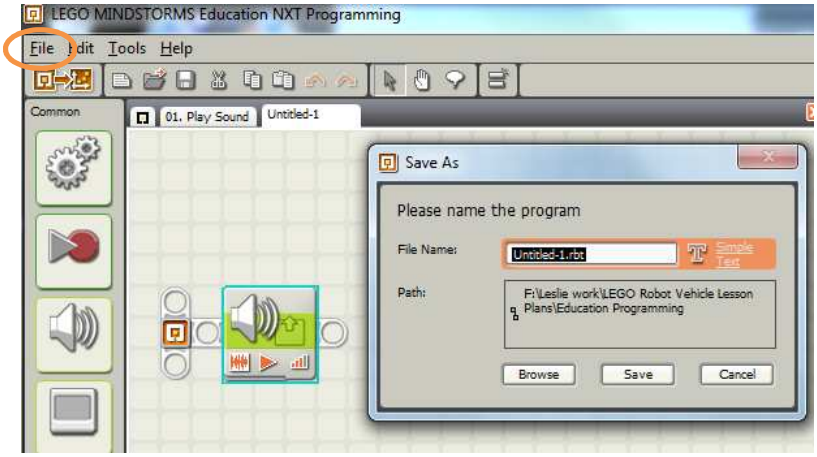
B. Open the LEGO Education Software program, NXT 2.1 Programming.

C. Using the NXT Brick

To turn on the NXT brick, press the orange button. To turn the brick off, press the gray rectangular button below the orange button and hold for 3 seconds. Use the gray arrows to scroll through selections on the screen.



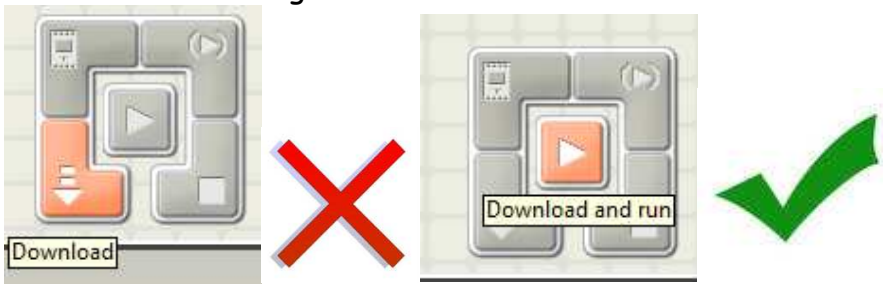
D. Saving Files



To save a programming file for later use, click "File -> Save", name the file, and choose a location to save the files using the browse button.

E. Downloading to the Brick

Since the vehicle will be moving, it is best to download the program, disconnect the vehicle from the computer, place on the floor, and run the program from the vehicle. You do not want the vehicles rolling off of the tables.



F. Locate Downloaded Files

Press the orange button on the vehicle once to select "My Files" and again to select "Software Files".

The last file you downloaded to the vehicle will appear on the screen. Use the left and right arrow keys to move to different downloaded files. Press the orange button to select the file. Press the orange button again to run the file. Make sure your vehicle is on the floor prior to running the file.

G. Opening LEGO Education Tutorials

Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

Each training activity will have a Play Button, Building Guide and Programming Guide. The Play Button will demonstrate the activity; the Building Guide is not needed since we are using pre-assembled intelligent vehicles. The Program Guide will walk you through the programming activity.

Step 2. Training Activity 12. Detect Sound (Stop for an Emergency Vehicle)

The entire class may either watch video #6 online from the following link or view them in groups on each laptop on the desktop in Lesson 3 folder.

Move to the Right for Sirens and Lights
http://www.youtube.com/watch?v=wX2mqUpP5gY&feature=related

A. Open a new programming file by clicking "GO" in the "Start New Program" area.

B. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

C. Click on Activity 12. Detect Sound

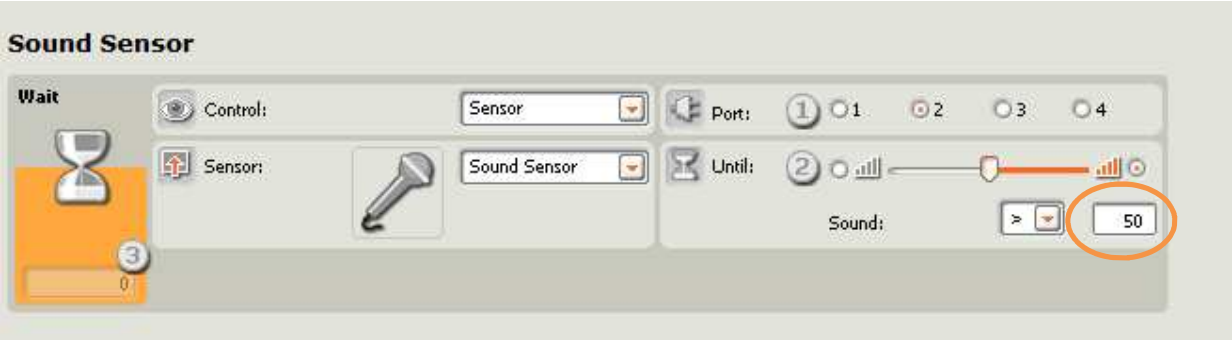
D. Scroll through the "Challenge Brief" using the right and left double arrows.

E. Click the "Programming Guide" bar and use the right and left double arrows to view the programming tutorial.

F. Complete the program as illustrated.

G. Connect the USB cable to the computer and the intelligent vehicle. Download and run the program by clicking the "Play" button in the center of the controller.

> If the intelligent vehicle stops from other noises in the room, increase the trigger value in the "Wait" configuration panel. You may use your voice or clap to simulate a siren.



Step 3. Pull over for Emergency Vehicles

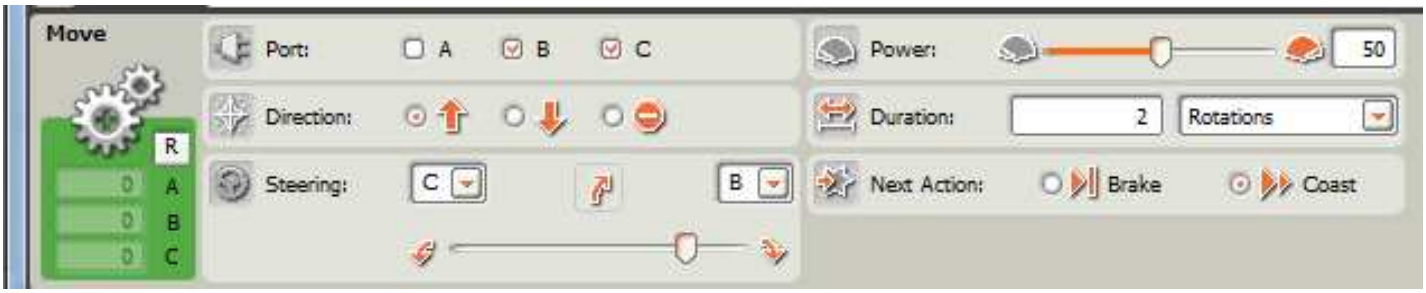
Source http://en.wikipedia.org/wiki/Image:Losangelesfiredepartmentambulance.jpg)

Program your intelligent vehicle to detect an emergency vehicle, pull off the road and stop. An emergency vehicle siren is loud and we cannot program here for a specific frequency. Students may need to try different trigger values. Watch the demonstration video #7 on each laptop or as a class entitled, "Pull over for Emergency Vehicle" in the Lesson 3 folder.

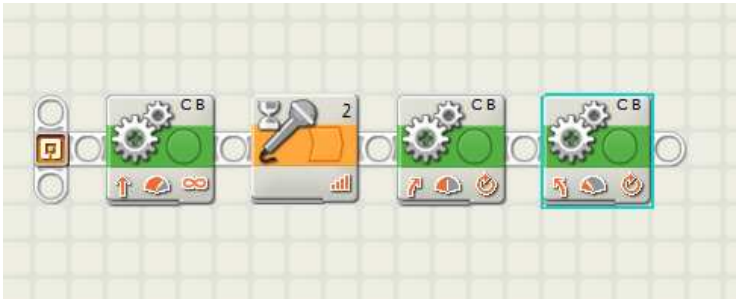
Try to program the exercise first. If you need help, review the example file named "Siren Pull Over.rbt" in Lesson 3 file folder.

A. Using the programming file from Step 2, Activity 12. Detect Sound, click the last move block and open the configuration panel.

B. Change the "Direction" to straight, set the "Duration" to 2 rotations, "Next Action" to coast, and move the "Steering" slider slightly right to maneuver the vehicle out of the way.



C. Drag another move block to the workspace.



D. Straighten the vehicle out by moving the "Steering" slider to the left to align with the roadway, reduce the "Power" to slow the vehicle, and set the "Duration" to 2 rotations, and "Next Action" to coast.

This is only an example. Students may come up with several variations.

Step 4. Follow a School Bus Route

(Source:http://commons.wikimedia.org/wiki/File:School_bus.jpg)

A school bus follows the same route every day. Students will program the intelligent vehicle to act as a bus on a route. For this exercise, the route is a 15 inch wide by 24 inch long rectangle.

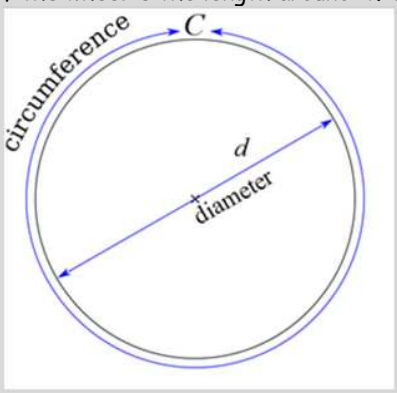
Watch the demonstration video # 8 in the Lesson 3 folder titled "Bus Route" in groups on each laptop or together as a class. Try to program the exercise first. If you need help, review the example file named "Bus Route.rbt" in Lesson 3 file folder.

MATH MOMENT!

Calculating Travel Distance

In order to program the bus to travel 15 inches, students can choose a duration of "unlimited", "degrees", "rotations", or "seconds" from the "Move" configuration panel. To provide an accurate travel distance, we will program the number of wheel rotations.

The circumference of the wheel is the length around it. One wheel rotation equals one circumference of the wheel.



Diameter of wheel is 2.25 in

$$One\ wheel\ Rotation = Circumference = \pi \times diameter$$

What is the circumference of the intelligent vehicle wheel?

$$C = \pi \times d = 3.14 \times 2.25\ in = 7.065\ inches$$

The distance traveled in inches is the number of wheel rotations multiplied by the circumference of the wheel. In this case we already know the distance traveled and need to calculate the number of rotations.

Therefore:

Distance traveled = circumference x wheel rotations

$$15\ inches = C \times rotations$$

To calculation the number of rotations to travel a certain distance is

$$\#\ rotations = Distance\ traveled \div C$$

$$= (15\ inches) \div (7.065\ inches) = 2.12\ rotations$$

Calculate the number of rotations to travel 24 inches.

Program the Bus Route

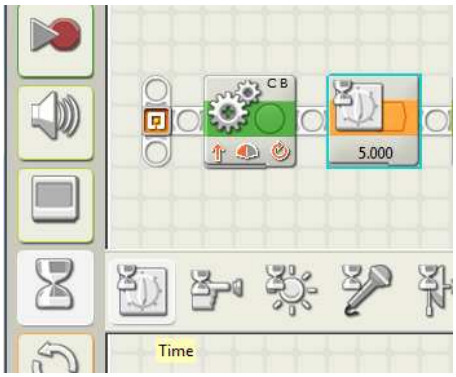
A. Open a new programming file.

B. Select the move block, drag and drop.

C. In the "Move" configuration panel, select rotations for duration and enter 2.12 rotations to travel 15 inches.

D. Reduce power to 50.

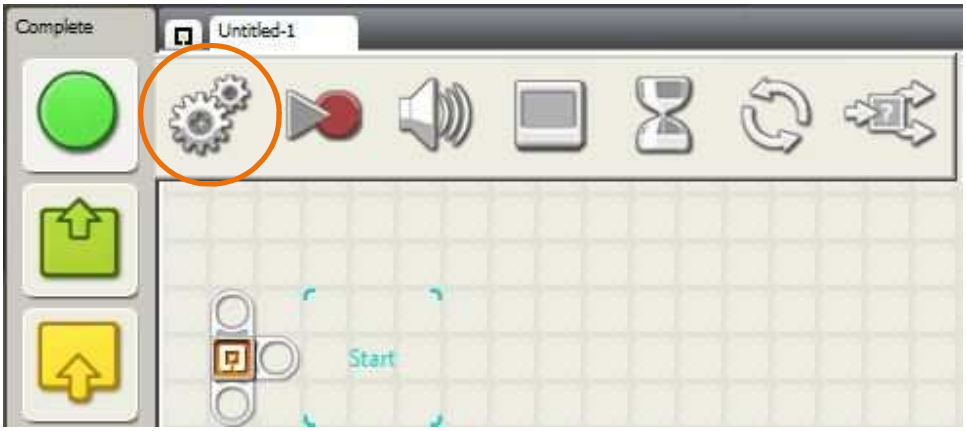
E. Insert a wait block for 5 seconds to pick up passengers.



In order to turn accurately on the black line, the right wheel (port B on brick) will need to remain stationary and the left wheel (port C on the brick) will need to rotate 350 degrees to turn the intelligent vehicle 90 degrees to the right. In order to move only one wheel, the Complete Palette menu will need to be used. The complete palette menu provides more options for more complicated programming. We will only be using the move block to isolate one wheel. Once the move block for turning is finished, switch back to the Common Palette.

F. Switch to complete palette by clicking the "Complete Palette" tab.

G. Click on the "Common" button (green, round circle) and drag and drop a "move" block to the workspace.



H. Uncheck port "B" (right wheel) from the "Move" configuration panel (we only want the left wheel of port "C" to move).

I. Reduce the "Power" to 50.

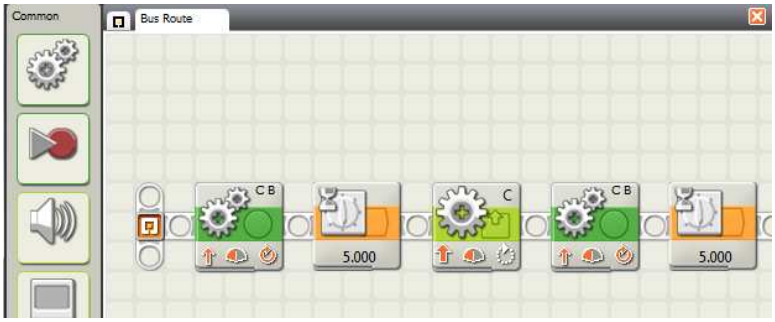
J. Set the "Duration" to 350 Degrees.

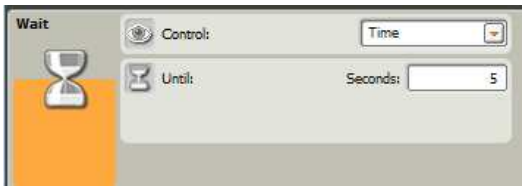
K. Switch back to the "Common Palette"

L. Calculate the number of rotations to travel 24 inches.

M. Repeat steps A – D and change the number of rotations to 3.4 to make the bus travel the 24 inches to the next stop.

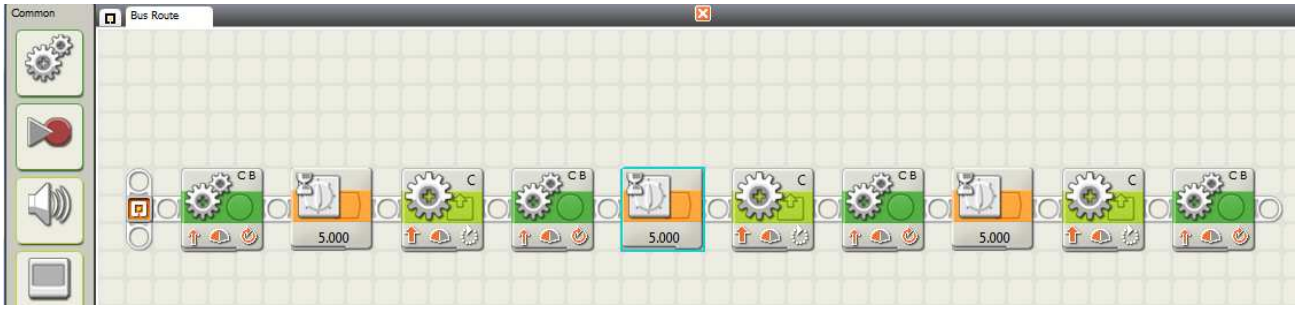
N. Program the bus to stop for 5 seconds to pick up passengers.





O. Finish the program by repeating a turn (steps F – K), travel 15 inches (steps B – D), wait 5 seconds (step E), turn (steps F – K), travel 24 inches to return to the starting point (steps B – D).

The complete bus route should look like the illustration below.



P. Once your program is complete, downloaded it to your intelligent vehicle and run on the bus route.

> Did the vehicle follow the bus route?
>
> The travel distance is based on the wheel rotations. Where should the wheel be placed at the starting point?
>
> You program to turn right pivoting on the right wheel. Should the right wheel or left wheel be on the black line?

Q. Additional Challenge

For an additional challenge (if time allows), create your own route with pedestrians and other vehicles to avoid (creating an obstacle course on the floor). Create your route on the floor using objects in the room such as a water bottle to avoid. Create a program for your route and run.

Step 5. Mini Assessment

Hand out mini assessment 3 for the students to complete.

Teacher Guide

Lesson 4: Follow a Route and Calculate Travel Time Exercise – Light Sensor,

Objectives in this session

1. Demonstrate travel time calculations
2. Calculate travel time of intelligent vehicle for given route
3. Program an intelligent vehicle for given route
4. Run and test intelligent vehicle route program
5. Evaluate, refine and solve programming problems, as necessary

What You Need

One set for entire class:

- Example programming files located on laptop desktop
  16. Detect Dark Line
  17. Follow a Line
  Follow a line-travel time
- Videos # - 9. Kiva Robots
  10. The Dance of the Bots
- ¾ inch black electrical tape
- Stop watch or timer (for additional challenge)

One for each robot group:

- Laptop with LEGO Education Software
- LEGO Education Kit 9797
- From the LEGO Education kit, pre-built robot vehicle
- From the LEGO Education kit, USB computer to robot cable
- Student Guide

One for each student

- Lesson 3 Review
- Mini Assessment 4

Agenda		
Step	***Time***	***Activity***
1	10 min	*Review Lesson 3*
2	15 min	*Training Activity 16. Detect Dark Line – Stop at an Intersection Stop Bar*
3	25 min	*Training Activity 17. Follow a Line – Follow a Route*
4	15 min	*Calculate Travel Time*
5	15 min	*Calculate travel time for a route*
6	10 min.	*Mini Assessment 4*
Total	1.5 hrs	

Getting Ready

Using the pre-built LEGO robot vehicles, make sure batteries are fully charged for robots and laptops. Teachers may want to pre-determine a naming convention and location for students to save files.

Using black electrical tape, make a line 5 feet long. The line will be used in steps 2-5.

Step 1. Review Lesson 3

A. Definition Review

Congestion mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Circumference – one wheel rotation or $\pi \times diameter$
Distance traveled = circumference x wheel rotations
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely
Transportation engineer – person who works to move people and goods safely and efficiently
Traffic congestion - overcrowded or clogged roadways that prevent people from moving efficiently
Travel time – how long it takes to get from A to B

Intelligent vehicles of the future may use sensors in the pavement or roadways to maneuver. The following videos show a robot developed to automate a catalog warehouse distribution center. The robots use sensors in the floor to move products around the warehouse. Intelligent vehicles in the future may work in a similar fashion. Similar systems could be developed to distribute people and goods safely and efficiently.

http://commons.wikimedia.org/wiki/File%3APort_Santos.jpg

B. The entire class may either watch the following videos online from the following link or view them in groups on each laptop (video file #9 and #10 can be found in the Lesson 4 folder on the desktop).

Kiva Robots
http://www.youtube.com/watch?v=4kl6PhWfwjA
The Dance of the Bots
http://www.youtube.com/watch?v=Vdmtya8emMw

Step 2. Training Activity 16. Detect Dark Line (Stop at an Intersection Stop Bar)

Open the LEGO Education Software program, NXT 2.1 Programming.

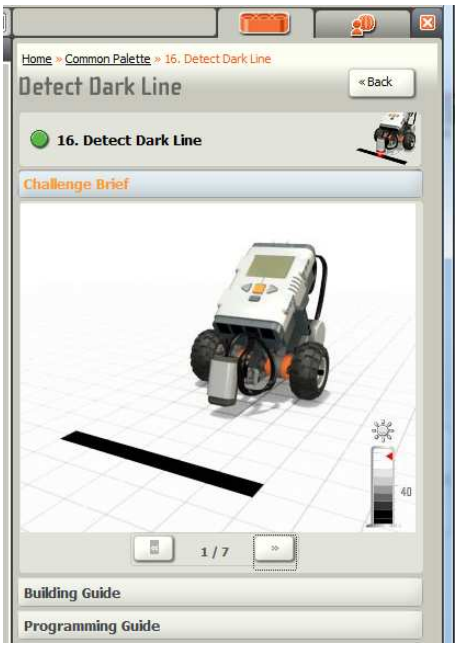
Refer to past lessons for managing memory, saving files, downloading to the brick and other basic skills.

A. Begin by starting new program file and clicking "GO" in the "Start New Program" area.

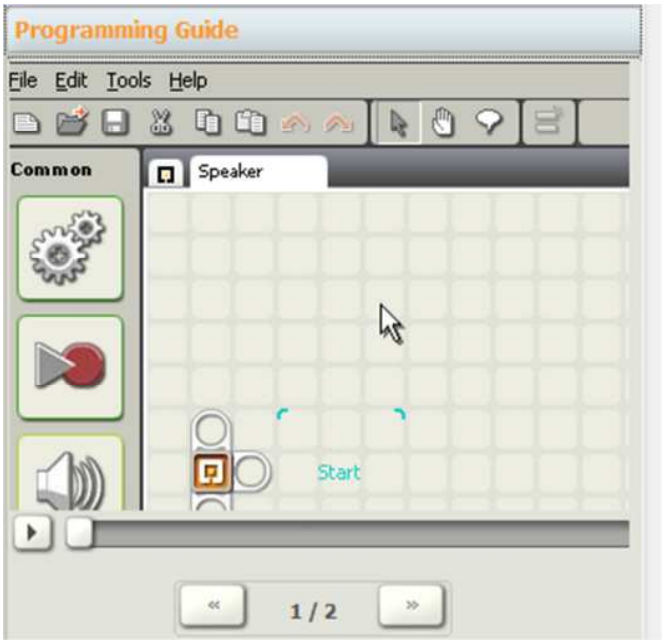
B. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

C. Click on Activity 16. Detect Dark Line

D. By default, the Challenge Brief will be shown. Click on the double arrow buttons to view the activity.



E. Click the "Programming Guide" bar (you may need to use the scroll bar on the far right to find it) and watch the tutorial that shows how to drag the desired icon(s) into the workspace.



In step 4 of the "Programming Guide", the light sensor is programmed to wait to be activated by a certain intensity of light.

If your intelligent vehicle is running on a surface of any color other than white before detecting the black line, an adjustment to the trigger value may be needed. The orange arrow on the left above is the feedback box which displays the current light reading (0-100%). You can use it to try out different trigger values.

Select the left radio button (step 6 of tutorial) to program the block with light levels lower than the trigger value. If you check the "Generated Light" checkbox, the light sensor will turn on its own small light source and detect this light if it is reflected back to it.

Complete the program as illustrated to make the intelligent vehicle stop at an intersection stop bar (represented by the black tape).

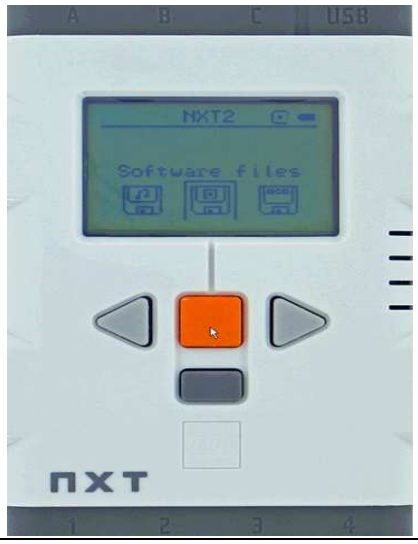
F. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "Download" button in the bottom left corner of the controller.

G. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

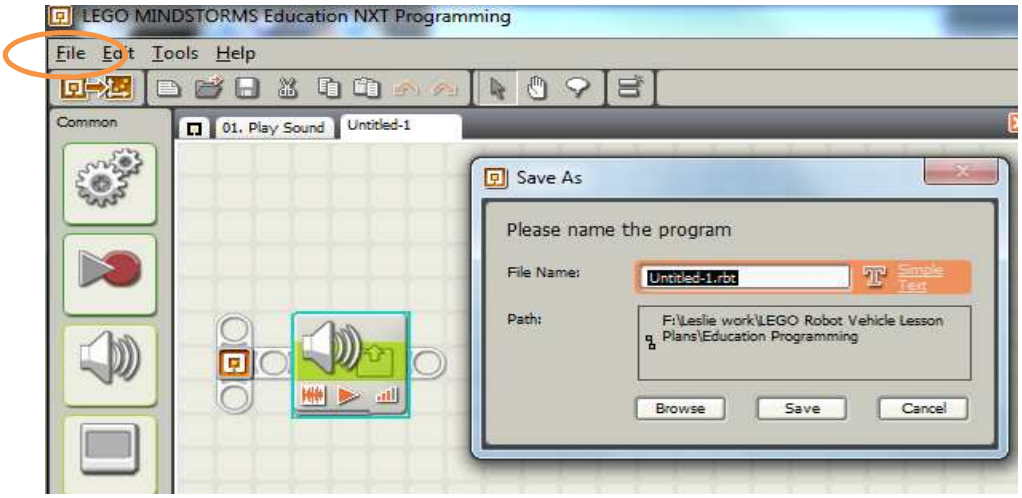
H. Place the vehicle a short distance from the stop bar (black tape) and run the program.

> The last file you downloaded to the vehicle will appear on the screen. Use the left and right arrow keys to move to different downloaded files. Press the orange button to select the file, press the orange button again to run the file. Make sure your vehicle is on the floor prior to running the file.

I. Press the orange button on the vehicle once to select "My Files" and again to select "Software Files".

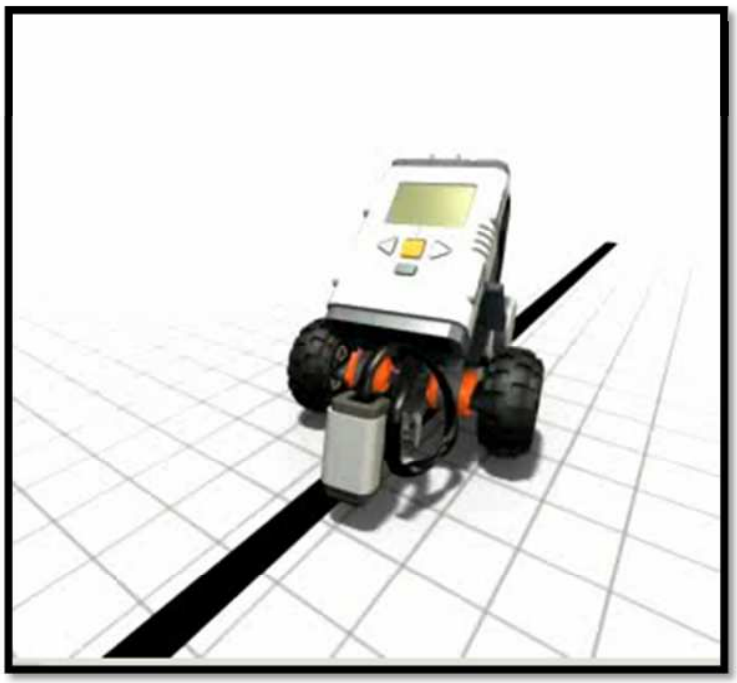


J. To save your programming file to use again, click "File -> Save", name the file and find the location to save files using the browse button. Teachers may want to pre-determine a naming convention and location for students to save files.



To return to the Common Palette, click the "Back" button in the upper right hand corner of your window.

Step 3. Training Activity 17. Follow a Line (follow a route)



A. Open a new programming file.

B. Click on the back button in the Common Palette.

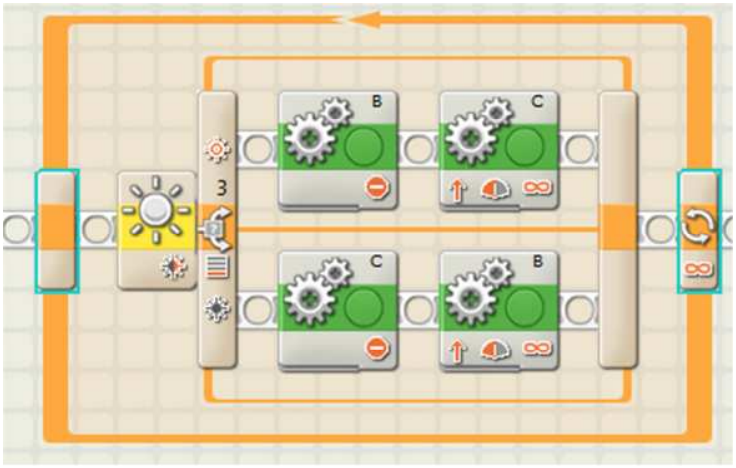
C. Click on Activity 17. Follow a Line in the Common Palette

D. Complete the program as illustrated, to make the intelligent vehicle follow a route (a black line.)

Loop Blocks and Switches

Loop block – any programming blocks inside the loop block will repeat in a loop (in this exercise, forever).

Switch block – in this program the light sensor switch block is used. If the light sensor detects a dark line, motor C (left wheel) will stop and motor B (right wheel) moves forward. If the light sensor then detects a lighter road surface, the right wheel stops and left wheel moves forward.



For additional information on the loop and switch block, see the help tab

E. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "download" button in the bottom left corner of the controller.

F. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

G. Place the vehicle at the beginning of the black line.

H. Run the program from the NXT brick (refer to Step 2, letter H for help).

I. Save the program for use in Step 5 (see Step 2, letter J for help).

Step 4. Calculate Travel Time

MATH MOMENT!

Calculating Travel Time

Have you ever used a mapping application to find out how long it will take you to drive from one destination to another?

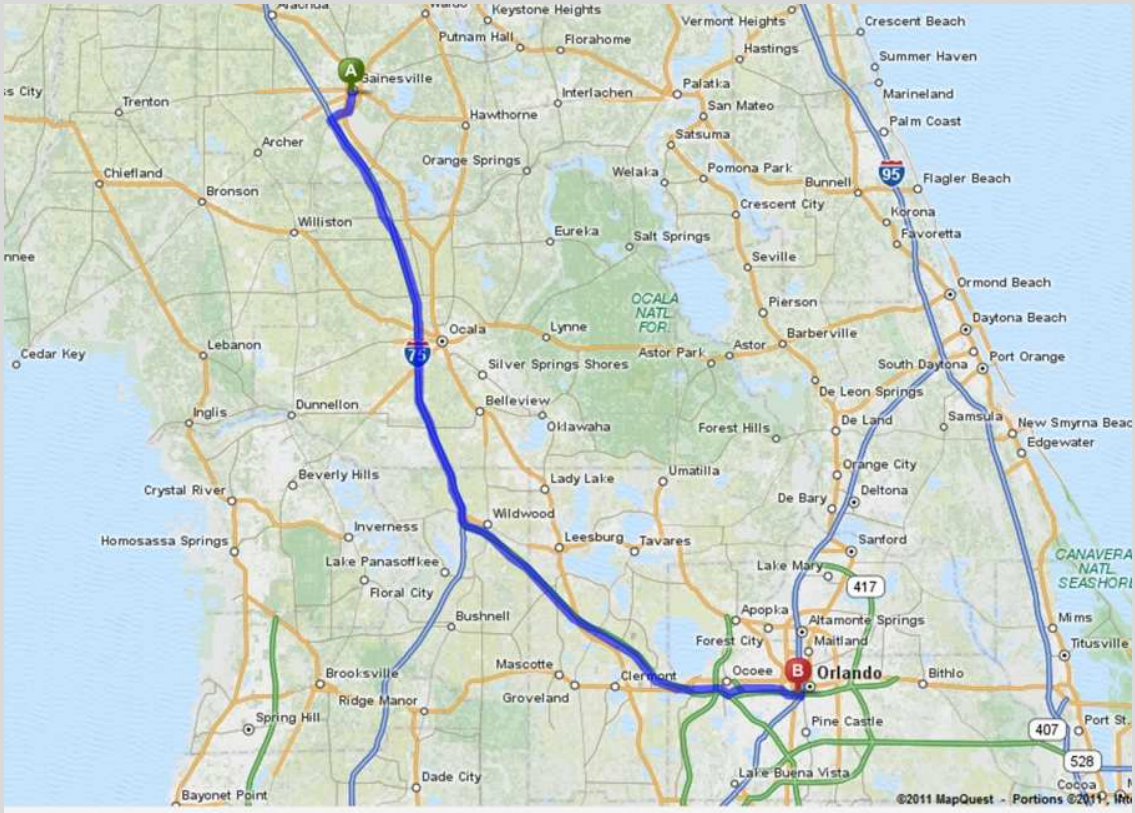
If you travel from Gainesville, Florida to Orlando, Florida, the distance is 120 miles. How long will it take to drive 120 miles (or what is the travel time)? Travel time is a function of distance and speed.

$$travel\ time\ (hours) = \frac{distance(miles)}{speed\ (miles\ per\ hour)}$$

Therefore if you travel at a constant 60 miles per hour,

$$travel\ time\ (hours) = \frac{120(miles)}{60\ (miles\ per\ hour)}$$

$$travel\ time = 2\ hours$$



Step 5. Calculate Travel Time for a Route

A. Using the five foot long route of tape on the floor, calculate the time for the intelligent vehicle to travel from one end to the other.

$$travel\ time\ (seconds) = \frac{distance(feet)}{speed\ (feet\ per\ second)}$$

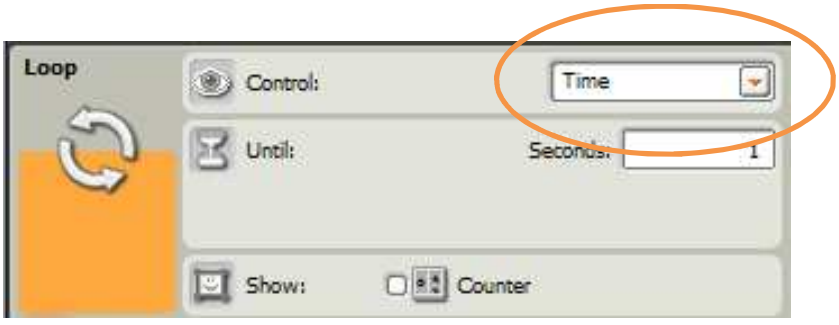
The constant speed for the intelligent vehicle following a route at 50% motor power (fully charged battery) is 0.19 feet per second.

$$travel\ time\ (seconds) = \frac{5(feet)}{.19\ (feet\ per\ second)}$$

travel time = 26.3 seconds

B. Use the program from Step 3 to make the intelligent vehicle stop after the calculated travel time.

C. Click on the existing "Loop Block". Change the loop control from forever to time, insert the travel time (in seconds), calculated above.



D. Download your program to the NXT brick.

E. Place your intelligent vehicle on the floor at the one end of the five feet of roadway (black tape).

F. Run the program (refer to Step 2, letter H for help).

Did your intelligent vehicle stop after 5 feet at the end of the roadway (black tape)?

G. Additional Challenge

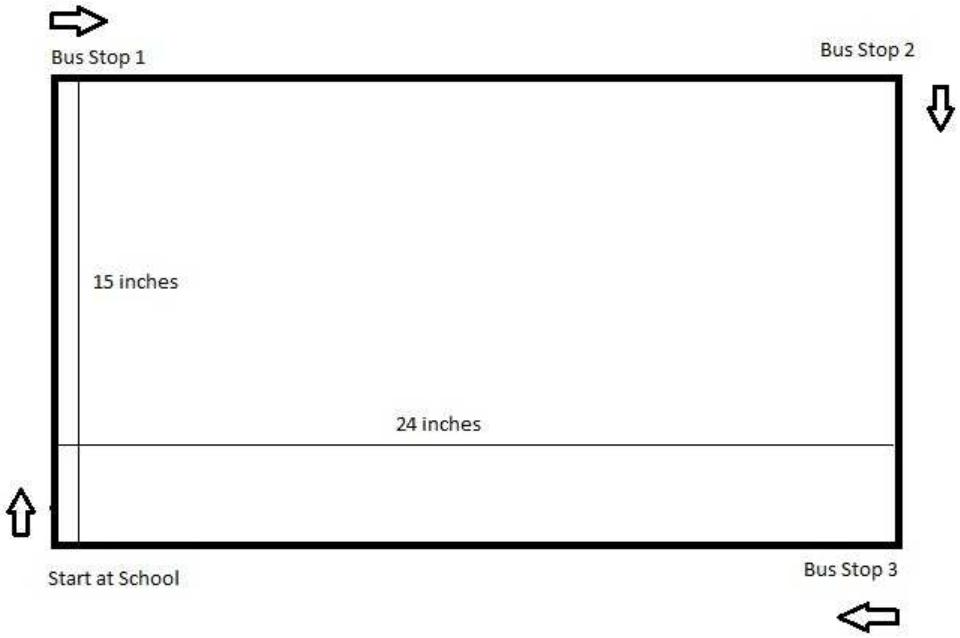
For an additional challenge (if time allows), calculate the travel time for the bus route in Lesson 3. To encourage the students to tackle the challenge, make it a competition. Which team gets the calculation correct first?

15 inches +15 inches+24 inches+24 inches = 6.5 feet

Using the average speed of 0.19 ft/sec,

6.5 feet divided by 0.19 ft/sec = 34.2 seconds

But what about the bus stops?



Using the average speed of 0.19 ft/sec and converting to inches equals 2.28 in/sec for speed.

Starting at school traveling 15 inches $travel\ time = \frac{15\ inches}{2.28\ in/sec}$=	6.58 seconds
Bus Stop 1 = wait	5 seconds
$travel\ time = \frac{24\ inches}{2.28\ in/sec}$=	10.52 seconds
Bus Stop 2 = wait	5 seconds
$travel\ time = \frac{15\ inches}{2.28\ in/sec}$=	6.58 seconds
Bus Stop 3 = wait	5 seconds
$travel\ time = \frac{24\ inches}{2.28\ in/sec}$=	10.52 seconds
Total travel time	49.2 seconds

Run the program and time the route using a timer or stopwatch to test your calculations. Do the travel time measurement and calculations match? Why not?

Was your speed constant? (Answer: No, the acceleration and deceleration over a short distance made the average speed inaccurate.)

Step 6. Mini Assessment

Hand out mini assessment 4 for the students to complete.

Teacher Guide

Lesson 5: Pedestrian and Vehicle Detection Exercise – Ultrasonic Sensor

Objectives in this session

1. Program ultrasonic sensor on intelligent vehicle to mitigate congestion
2. Run and test intelligent vehicle programs constructed
3. Evaluate, refine and solve programming problems, as necessary

What You Need

One set for entire class:

- Example programming files located on laptop desktop
  14. Detect Distance
  Detect Distance Extra
  Pedestrian Detection

Videos #11 - Volvo Pedestrian Detection

- ¾ inch black electrical tape

One for each robot group:

- Laptop with LEGO Education Software
- LEGO Education Kit 9797
- From the LEGO Education kit, pre-built robot vehicle
- From the LEGO Education kit, USB computer to robot cable
- Student Guide

One for each student

- Lesson 4 Review
- Mini Assessment 5
- Post Test Questionnaire

Agenda		
Step	***Time***	***Activity***
1	10 min	*Review Lesson 4*
2	20 min	*Training Activity 14 Detect Distance – Stop for a Pedestrian*
3	35 min	*Stop for a Pedestrian and then continue*
4	10 min	*Mini Assessment 5*
5	15 min.	*Post Test Questionnaire*
Total	1.5 hrs	

Getting Ready

Using the pre-built LEGO robot vehicles, make sure batteries are fully charged for robots and laptops. Teachers should review the LEGO Mindstorm User Guide located on the laptop desktop prior to class. Teachers may want to pre-determine a naming convention and location for students to save files.

Step 1. Review Lesson 4

A. Definition Review:

Circumference – one wheel rotation or $\pi \times diameter$
Congestion mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Distance traveled = circumference x wheel rotations
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely
Transportation engineer – person who works to move people and goods safely and efficiently
Traffic congestion - overcrowded or clogged roadways that prevent people from moving efficiently
Travel time – how long it takes to get from A to B

Step 2. Training Activity 14. Detect Distance (Stop for a Pedestrian)

The entire class may either watch video #11 online from the following link or view them in groups on their laptop on the desktop in Lesson 3 folder.

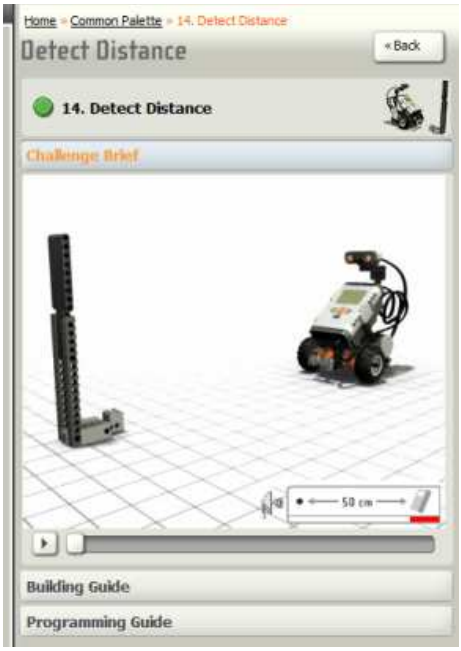
Volvo Pedestrian Detection
http://www.youtube.com/watch?v=wPUGwbpfVhQ

A. Open the LEGO Education Software program, NXT 2.1 Programming.

B. Begin by starting new program file by clicking "GO" in the "Start New Program" area.

C. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

D. Click on Activity 14. Detect Distance



E. By default, the Challenge Brief will be shown. Click on the Play Button to view the activity.

F. Click the "Programming Guide" bar (you may need to use the scroll bar on the far right to find it) and watch the tutorial that shows how to drag the desired icon(s) into the proper window.

G. Complete the program as illustrated to make the intelligent vehicle stop short of the "pedestrian".

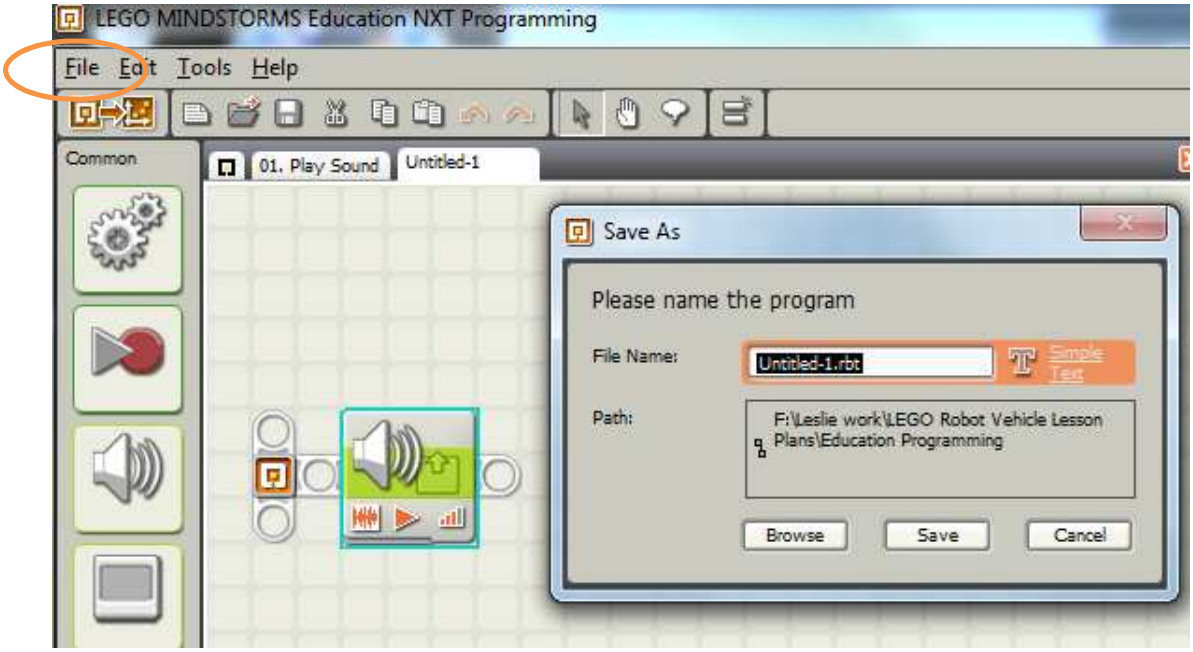
H. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "download" button in the bottom left corner of the controller.

I. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

J. Place the vehicle in front of the "pedestrian" and run the program from the intelligent vehicle. Rather than using a tower structure like the picture in the Challenge Brief, you may use your hand, a doll, or a LEGO structure to simulate a pedestrian in the path of the vehicle.

In the video, the car uses a camera and radar (electromagnetic waves) system. Our intelligent vehicle uses an ultrasonic (sound waves) sensor. The ultrasonic sensor sends out a sound wave. When the wave hits an object, it is reflected back to the sensor. The ultrasonic sensor calculates the distance of the object based on the time it takes for the wave to return to the sensor.

K. To save your programming file to use again, click "File -> Save", name the file and find the location to save files using the browse button. Teachers may want to pre-determine a naming convention and location for students to save files.



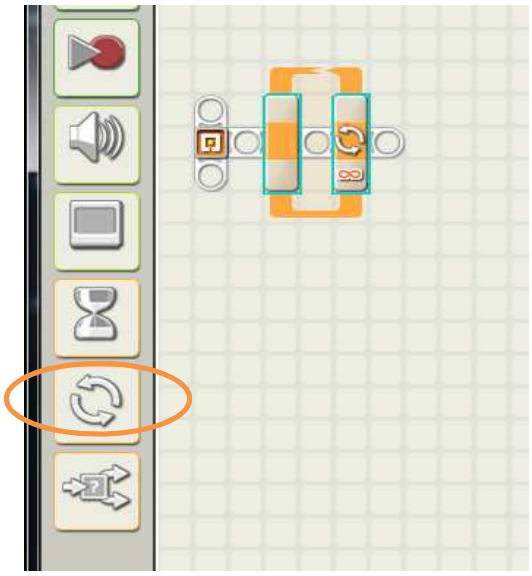
To return to the Common Palette, click the "Back" button in the upper right hand corner of your window.

Step 3. Stop for a Pedestrian and then Continue

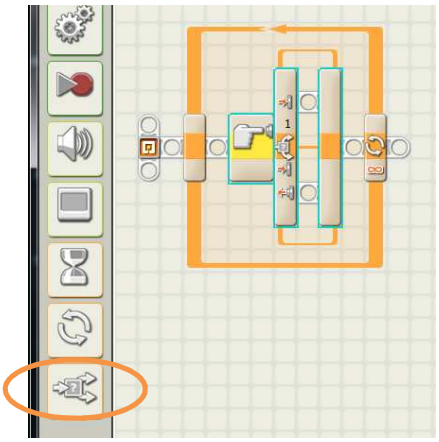
> Challenge the students to program the vehicle to stop for a pedestrian and then continue when the pedestrian moves out of the way without using the following tutorial.

A. Open a new programming file.

B. Drag a "Loop" block onto the workspace.

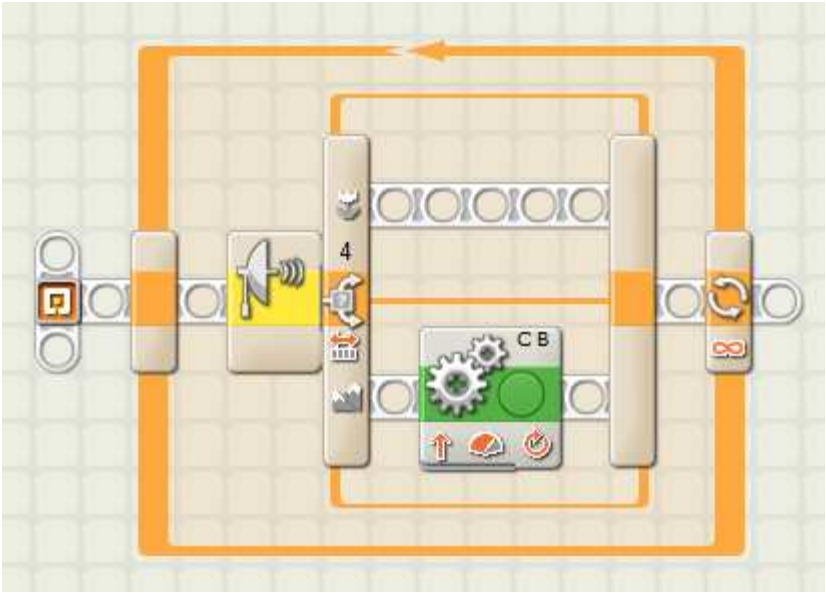


C. Drop a "Switch" block inside the "Loop" block.



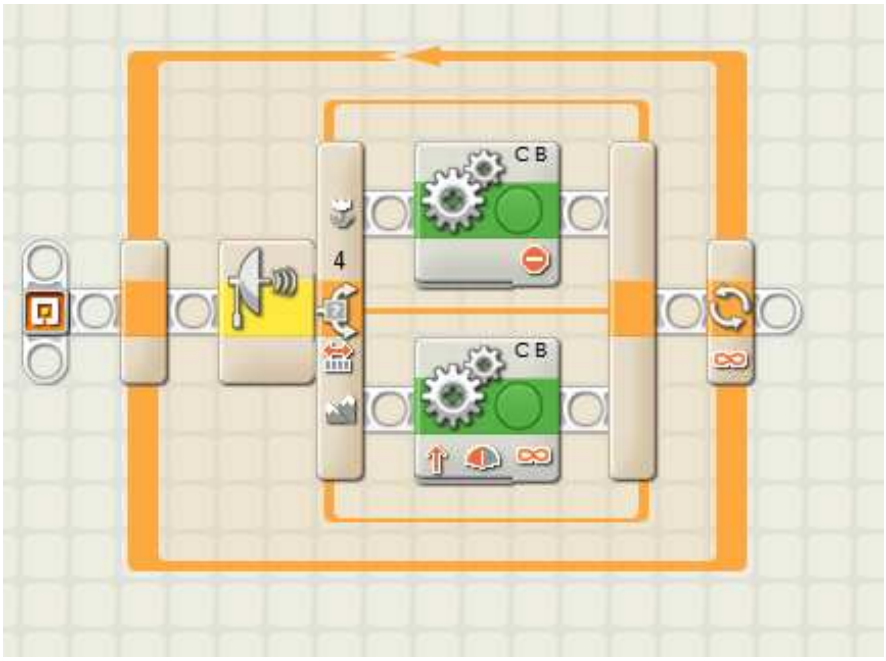
D. Change the settings in the "Switch" block configuration panel from the default ("Touch Sensor") to "Ultrasonic Sensor" and set the "Distance" to 15 inches.

E. Drop a "Move" block on the bottom row of the "Ultrasonic Sensor" "Switch" block.



F. In the "Move" configuration panel, change the "Power" from 75 to 50.

G. Drop another "Move" block on the top row of the "Ultrasonic Sensor" "Switch" block.



H. Change the "Direction" to "Stop" in the "Move" configuration panel.

I. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "download" button in the bottom left corner of the controller.

J. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

K. Place the vehicle at a starting point greater than 15 inches away from an object.

L. Run the program from the NXT brick.

Did the vehicle stop 15 inches away from the object? Move the object and the vehicle should begin to move forward again.

M. Place another object in the vehicles path.

Did the vehicle stop 15 inches away from the object?

N. Save the program.

O. Additional Challenge 1

For an additional challenge, program the intelligent vehicle similarly to the video. Add a sound and display a warning for the driver when a pedestrian is at a pre-determined distance and then have the vehicle stop when the pedestrian is closer.

Additional Challenge 2

Which student team can get as close as possible to another vehicle without touching it? Use any available object to simulate the other vehicle as long as the object is tall enough to be sensed by the ultrasonic sensor. A wall can also be used.

Step 4. Mini Assessment

Hand out mini assessment 5 for the students to complete.

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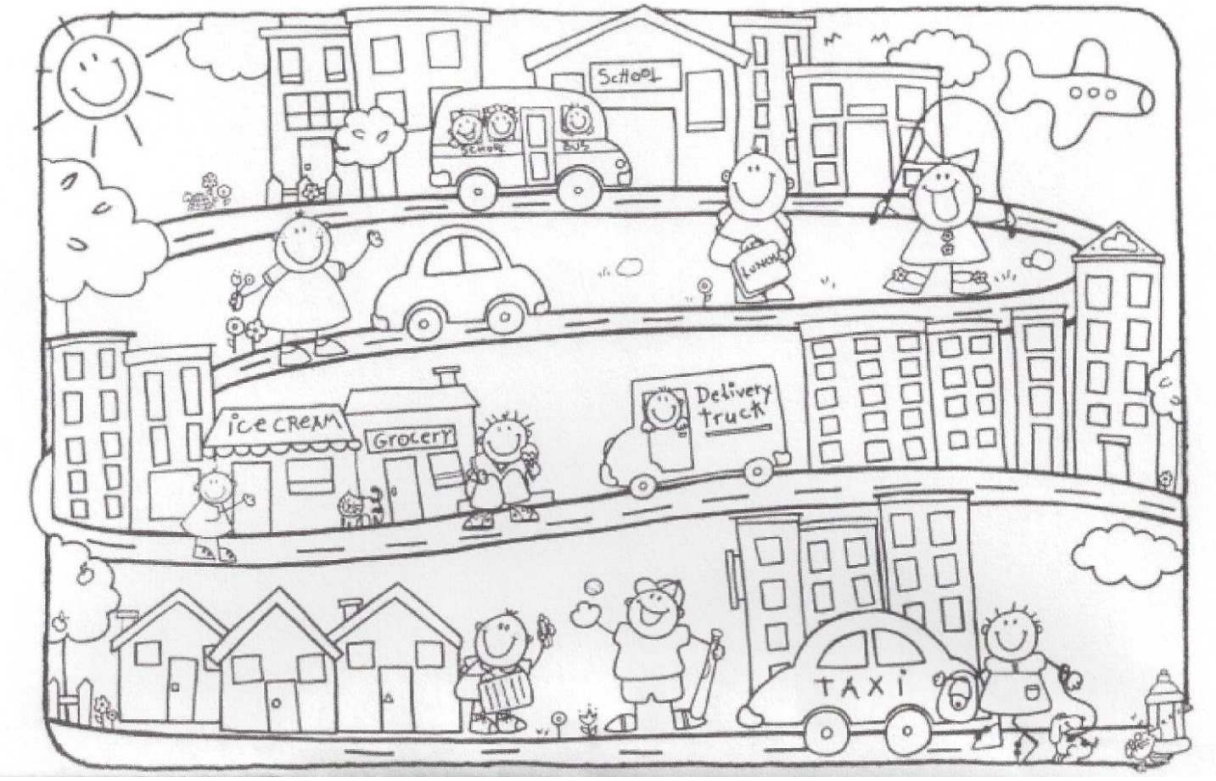
Lesson Reviews

Lesson 1 Review



How many different types of vehicles do you see in the above picture?

Can you name any other types of transportation?

What would happen if there were too many vehicles in one area?

List some problems that could occur.

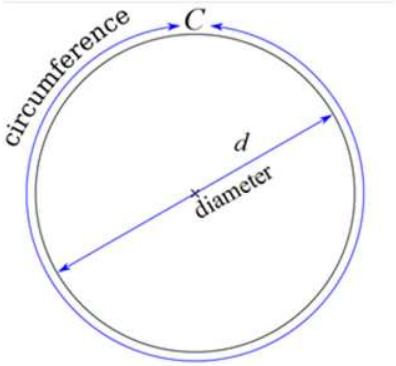
Lesson 2 Review

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

What features would you want your intelligent vehicle of the future have to mitigate congestion?

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car.

Lesson 3 Review



Diameter of wheel is 2.25 in

$$One\ wheel\ Rotation = Circumference = \pi \times diameter$$

What is the circumference of the intelligent vehicle wheel?

$$C = \pi\, x\, d =$$

Distance traveled = circumference x wheel rotations

If you program you intelligent vehicle to move 3 rotations, what is the distance it will travel?

Lesson 4 Review

Match the words with their definition.

Circumference	circumference x wheel rotations
Congestion mitigation	person who works to move people and goods safely and efficiently
Distance traveled	one wheel rotation or ∏x diameter
Engineer	overcrowded or clogged roadways that prevent people from moving efficiently
Intelligent Transportation Systems (ITS)	how long it takes to get from A to B
Transportation Engineer	providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Traffic congestion	person who applies science, math and creativity to solve problems
Travel time	using technology to make the roadways in a city or town operate more efficiently and safely

Mini Assessments

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

Write down 3 examples of negative effects of traffic congestion.

What does it mean to "mitigate congestion"?

Mini Assessment 2

An engineer applies _____, _____ and _____ to solve problems.

Traffic Engineer's work to move _____ and _____ efficiently.

ITS stands for _____.

What else would you want to program your intelligent vehicle to say or display that could reduce traffic congestions?

Mini Assessment 3

Give 3 examples of how an intelligent school bus reduces roadway congestion?

Would an emergency vehicle detector improve roadway safety?

If so, why?

If not, why not?

Mini Assessment 4

A bus driver is driving students to school. It takes her 1 hour to cover the whole bus route (which is 15 miles long). What is the bus' average speed?

If this same bus added another stop to the route that was 5 miles away but kept the same average speed, how long would the bus route now take to complete?

SHOW YOUR THINKING with drawings or equations.

Mini Assessment 5

List 2 things that can cause congestion. For each of those things, list how an ultrasonic sensor might be able to mitigate (or prevent) that congestion.

Cause of Congestion	Way to use ultrasonic sensor to mitigate
1.	
2.	

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Questionnaires

LEGO® Robot Intelligent Vehicle Lesson Plans
An Introduction to Transportation Engineering

Pre-Course Questionnaire

I have a computer at home. ☐ Yes ☐ No
I like or used to like playing with LEGOs. ☐ Yes ☐ No

What grade are you in? _____

Instructions: Read the sentences carefully.
Circle one best answer for each sentence.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
5	4	3	2	1	1. I like math.
5	4	3	2	1	2. I like science.
5	4	3	2	1	3. I can program a LEGO Mindstorm Robot.
5	4	3	2	1	4. I know what a transportation engineer does.
5	4	3	2	1	5. I understand what traffic congestion is.
5	4	3	2	1	6. I will consider going to college and becoming an engineer.
5	4	3	2	1	7. I will study hard at math and science.

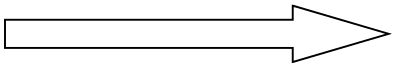
LEGO® Robot Intelligent Vehicle Lesson Plans
An Introduction to Transportation Engineering

Post-Course Questionnaire

Instructions: Read the sentences carefully.
Circle one best answer for each sentence.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
5	4	3	2	1	1. I like math.
5	4	3	2	1	2. I like science.
5	4	3	2	1	3. I can program a LEGO Mindstorm Robot.
5	4	3	2	1	4. I know what a transportation engineer does.
5	4	3	2	1	5. I understand what traffic congestion is.
5	4	3	2	1	6. I will consider going to college and becoming an engineer.
5	4	3	2	1	7. I will study hard at math and science.
5	4	3	2	1	8. Learning to program the robot by thinking logically will help me solve other problems.
5	4	3	2	1	9. The Lego Mindstorm Robot is easy to use.
5	4	3	2	1	10. The course helped me understand the use of math, science, and technology.
5	4	3	2	1	11. Learning about a transportation engineer was interesting.
5	4	3	2	1	12. I had enough time to complete the exercises.
5	4	3	2	1	13. The Lego robotics lessons were hard.
5	4	3	2	1	14. The Lego robotics lessons were fun.
5	4	3	2	1	15. I would like to take another robotics course.

Please read and answer the questions on the back.



Please write a brief answer to the next four questions.

1. What I will remember the most about this Introduction to Transportation Engineering Course is_____.

2. What is an engineer?

3. What would you like about being a transportation engineer?

4. What would you NOT like about being a transportation engineer?

Appendix B

Student Guide-Course Material

LEGO® Robot Vehicle Lesson Plans for Secondary Education – A Recruitment Tool for Transportation Engineering

Student Guide

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Disclaimer

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Acknowledgment of Sponsorship

This work was sponsored by a grant from the Center for Multimodal Solutions for Congestion Mitigation, a U.S. DOT Tier-1 grant-funded University Transportation Center.

Student Guide

Lesson 1: What does a Transportation Engineer Do?

Agenda		
Step	***Time***	***Activity***
Day 1		
1	15 min.	*Complete the pretest questionnaire*
2	50 min.	*Introduction to Transportation Engineering PowerPoint with embedded videos, slides*
3	10 min.	*Mini Assessment 1*
4	15 min	*LEGO Mindstorm NXT Intelligent Vehicle Demonstration*
Total	1.5 hrs	

Introduction to Transportation Engineering

UF UNIVERSITY of FLORIDA

Design Your Future – A Fun Job in Engineering

Click on image for video

What is an Engineer?

An **engineer** applies science, math, and creativity to solve problems.

What is a civil engineer?

- A civil engineer could design, build, and maintain things like bridges, roads, canals, pipelines, and buildings.

Erin Fletcher, a Civil Engineer

Click on image for video

Civil Engineering

Civil Engineers might study:

- Construction
- Soils
- Structures
- Land Development
- Water Supply
- Environment
- Transportation

Many Jobs of Civil Engineering

How many different jobs can you see?

Role of Transportation Engineer

To move people and goods safely and efficiently

Types of Transportation – How many can you name?

Transportation Engineers Move People Safely

What causes most vehicle crashes?

Mistakes made by drivers (driver error)

Click on image for video

Transportation Engineers Move People Efficiently

Traffic Congestion

Traffic congestion is over crowded or clogged roads that prevent people from moving efficiently.

Almost half of traffic congestion in America is from too many cars on the road

Other causes for congestion might be traffic crashes, road work, or weather events.

Traffic Congestion Results

- Wasted time and gas
- Late arrival for work, meetings, and school
- Increased air pollution
- Wear and tear on vehicles
- Stressed and frustrated drivers
- Problems for emergency vehicles to get to emergencies

Congestion wastes billions of dollars.

Travel Time and Congestion

- Travel time - how long it takes to drive from A to B
- Congestion increases travel time because drivers must drive slower

SPEED ↓ TRAVEL TIME ↑

Transportation Engineers Can Manage Congestion

- Plan for the future
- Design new roadways
- Expand existing roadways
- Manage traffic efficiently

Intelligent Transportation Systems (ITS)

- ITS is using technology to make the roadways in a city or town operate more efficiently and safely.

Intelligent Transportation Systems (ITS) Video

Click on image for video

Design Your Intelligent Vehicle

- What features would your intelligent vehicle of the future have to help prevent congestion on the roadway?

Examples of Existing ITS in Vehicles

- Rear video camera and driver display
  - car beeps at driver when backing up and getting close to object
- Automated parallel park
- Driving lights automatically turn on
- Car automatically breaking before a crash
- Blind spot detection

Review

- **Transportation engineer** – moves people and goods safely and efficiently
- **Traffic congestion** – is over crowded or clogged roads that prevent people from moving efficiently
- **Travel time** – how long it takes to get from A to B, congestion increases travel time because drivers must drive slower

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Student Guide

Lesson 2: LEGO Education Software Tutorials for an Intelligent Vehicle – Play Sound, Use Display and Movement

Agenda		
Step	***Time***	***Activity***
Day 2		
1	10 min	*Review Lesson 1 Worksheet*
2	15 min	*Introduction to LEGO Education Software-Getting Started*
3	15 min	*Training Activities 1 and 2 - Play Sound and Using Display*
4	40 min	*Training Activities 3-8, 10- Making your Intelligent Vehicle Move*
5	10 min	*Mini Assessment 2*
Total	1.5 hrs	

Step 1. Review Lesson 1

Complete Lesson 1 review worksheet.

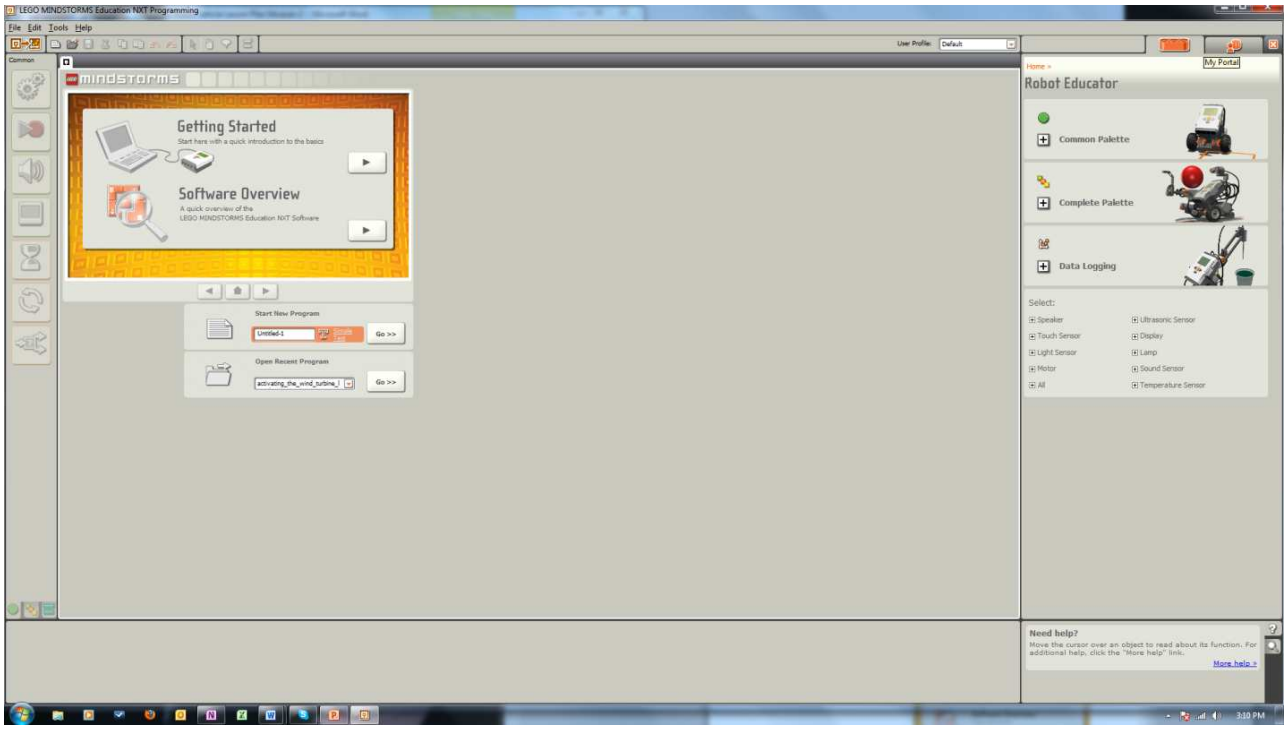
Definition Review
Congestion Mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams.
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely.
Traffic congestion - overcrowded or clogged roadways that prevent people and goods from moving efficiently
Transportation engineer – person who works to move people and goods safely and efficiently
Travel time – how long it takes to get from A to B

For review of an intelligent transportation system, the entire class may either watch the following video online from the following link or each group may view it on their laptop from the desktop in Lesson 2 folder.

Video #5 Ford Intelligent Vehicle Technology
http://www.youtube.com/watch?v=TFfy_LNyt-Y

Step 2. Introduction to LEGO Education Software

Open the LEGO Education Software program, NXT 2.1 Programming.



Getting Started

Teacher and students should watch both the "Getting Started" and "Software Overview" clips by clicking on the arrow to the right of each. You will need to continue to click on the arrow button when prompted to finish the video. This can be done either individually or on overhead screen as a class.

To turn on the NXT brick or select "ON" option on the screen, press the orange button. To turn the brick off, press the gray rectangular button below the orange button and hold. The gray arrows are for scrolling through selections.

Step 3. Training Activities 01. Play Sounds and 02. Using Display

Now students will begin programming their intelligent vehicle.

An intelligent vehicle will need to communicate with the passengers riding in the vehicle. The first activity students will learn is to program the vehicle to say "Stop". Students will then program the vehicle to show "Stop" on the dashboard.

Each training activity will have a Challenge Brief, Building Guide, and Programming Guide. The Challenge Brief will demonstrate the activity; the Building Guide is not needed since we are using pre-assembled intelligent vehicles; the Programming Guide will guide you through the programming activity.

Training Activity 01. Play Sound

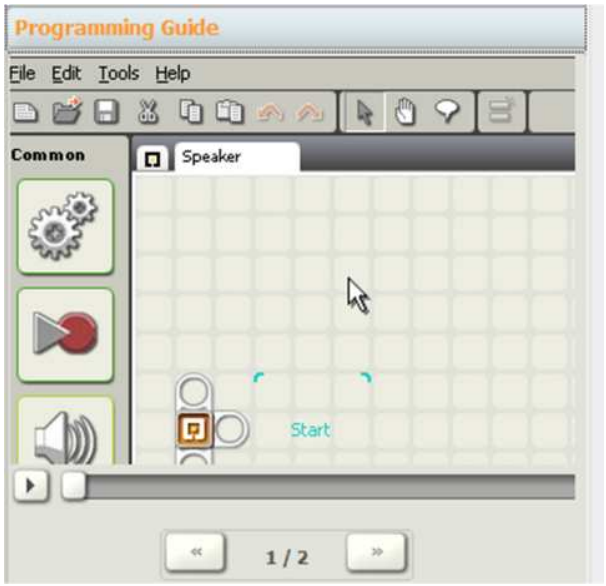
A. Begin by starting new program file by clicking "GO" in the "Start New Program" area.

B. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

C. Click on Activity 01. Play Sound

D. By default, the Challenge Brief will be shown. Click on the Play Button to view the activity.

E. Click the "Programming Guide" bar (you may need to use the scroll bar on the far right to find it) and watch the tutorial that shows how to drag the desired icon(s) into the proper window.



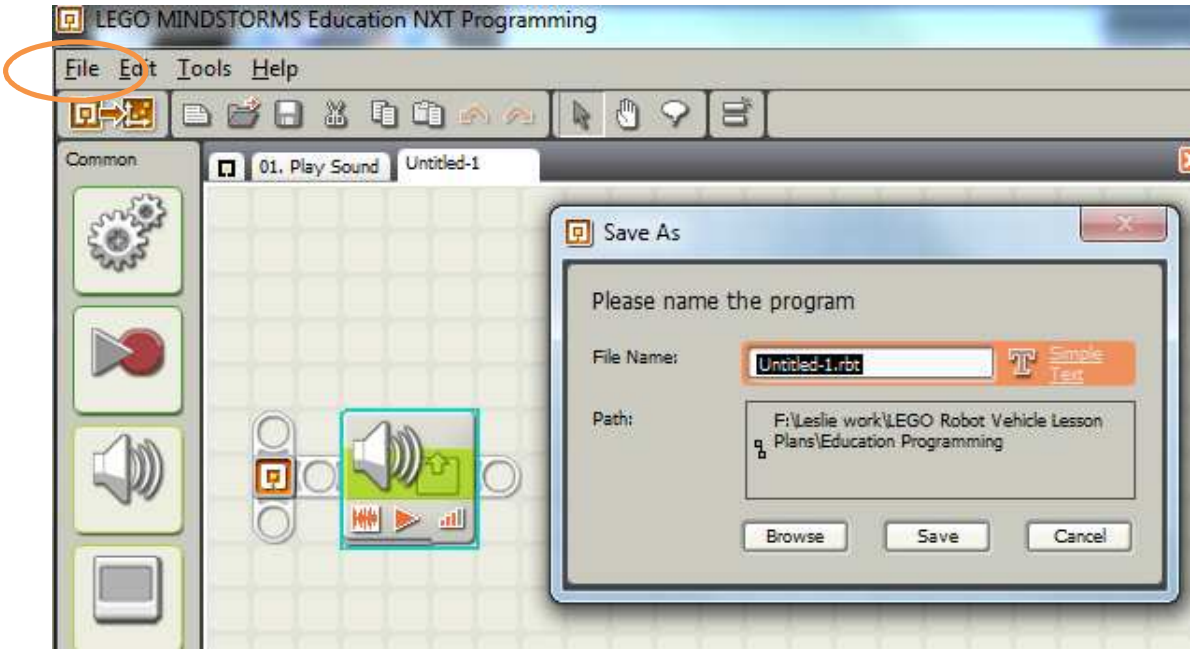
F. Complete the program as illustrated, but instead of selecting the "Error" file from the configuration panel, select the "Stop" file.

Configuration Panel

G. Connect the USB cable to the computer and the intelligent vehicle. Download and run the program by clicking the "Play" button in the center of the controller.

H. Did your intelligent vehicle say "Stop"?

I. To save your programming file to use again, click "File Save", name the file and find the location to save files using the browse button. Teachers may want to pre-determine a naming convention and location for students to save files.

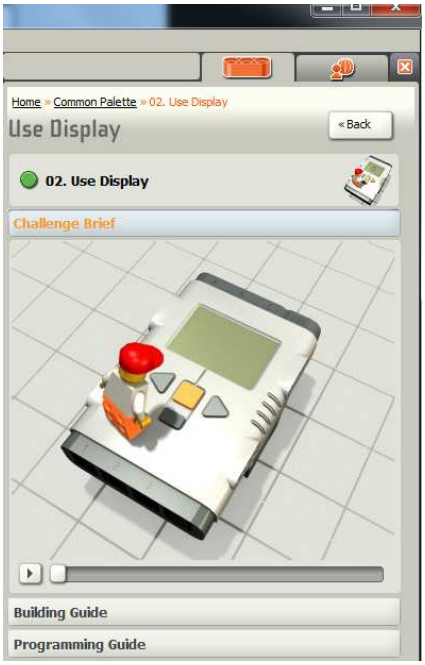


To return to the Common Palette, click the "Back" button in the upper right hand corner of your window.

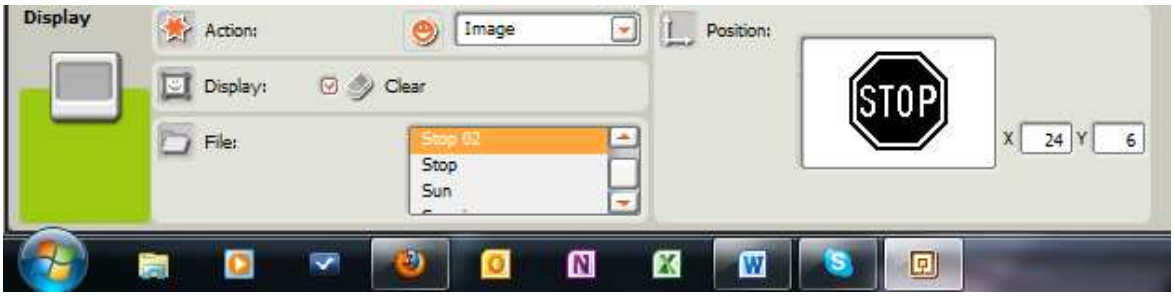
Training Activity 02 Use Display

A. Open a new programming file.

B. Click on Activity 02. Use Display in the Common Palette



C. Click on the "Programming Guide" bar and recreate the program from the guide (use the left and right arrow buttons to navigate). Instead of selecting "LEGO Minifig Head" from the configuration panel, select "Stop".



D. Connect the USB cable to the computer and the intelligent vehicle.

E. Download and run the program by clicking the "Play" button on the controller.

Did your intelligent vehicle screen or dashboard show a "Stop" sign?

To save your programming file to use again, click "File -> Save", name the file and find the location to save files using the browse button.

Step 4. Training Activities 3-10 Making your Intelligent Vehicle Move

Training Activity 03 Drive Forward

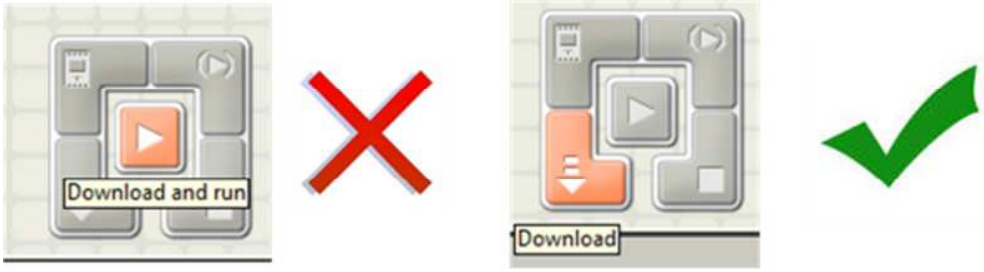
A. Open a new programming file.

B. Click on Activity 03. Drive Forward in the common palette.

C. Click on the "Programming Guide" bar and recreate the program from the guide (use the left and right arrow buttons to navigate).

This time instead of download and run, download the program to the intelligent vehicle. Since the vehicle will be moving, it is best to download the program, disconnect the vehicle from the computer, place on the floor, and run the program from the vehicle.

You do not want the vehicles rolling off of the tables.



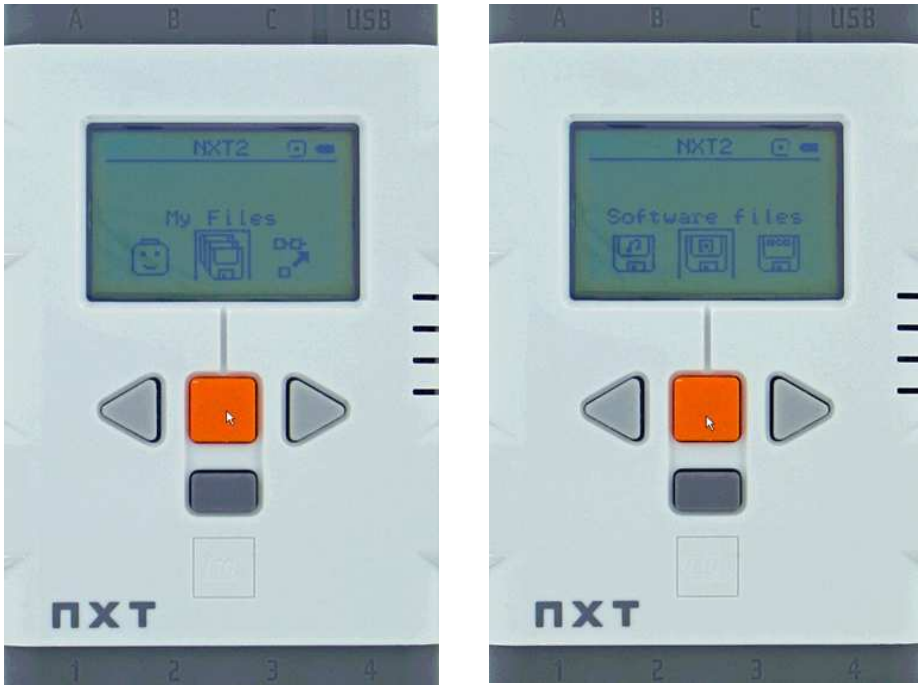
D. Connect the USB cable to the computer and the intelligent vehicle.

E. Download the program to the intelligent vehicle.

F. Disconnect the USB cable from the vehicle.

G. Place the vehicle on the floor.

H. Press the orange button on the NXT brick once to select "My Files" and again to select "Software Files".



I. Use the left and right arrow keys to find your file (the last file you downloaded to the NXT brick will appear first on the screen).

J. Press the orange button to select the file and again to run the file.

MAKE SURE YOUR VEHICLE IS ON THE FLOOR PRIOR TO RUNNING THE FILE!

K. Continue with common palette activities 4 through 8 and 10 ("Reverse", "Accelerate", "Curve Turn", "Point Turn", "Drive in a Square", and "Parking Bay"). **Skip Activity 9, "My Block"**.

L. Once you have completed training activities 1-8 and 10 you have completed Lesson 2 and are ready for the mini assessment.

Additional Challenge 1 - Program to "Park", "Display", and say "Stop" Using Display

Now that you have mastered how to make your intelligent vehicle move, program your vehicle to *"Park", "Display"* and *say "Stop".*

Additional Challenge 2

What else can you program your intelligent vehicle to say or display that could reduce traffic congestion? Program and run, be prepared to explain how your program reduces traffic congestion.

Step 5.Mini Assessment 2

Complete mini assessment 2.

Student Guide

Lesson 3: Detect Emergency Vehicle and Calculate Travel Distance Exercise – Sound Sensor

Agenda		
Step	***Time***	***Activity***
1	10 min	*Review Lesson 2*
2	10 min	*Training Activities 12 – Detect Sound*
3	20 min	*Pull over for an Emergency Vehicle*
4	40 min	*Follow a School Bus Route*
5	10 min.	*Mini Assessment 3*
Total	1.5 hrs	

Step 1. Review Lesson 2

A. Complete Lesson 2 review worksheet.

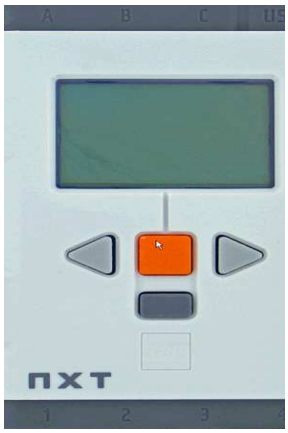
Definition Review

Congestion Mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams.
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely.
Traffic congestion - overcrowded or clogged roadways that prevent people from moving efficiently
Transportation engineer – person who works to move people and goods safely and efficiently
Travel time – how long it takes to get from A to B

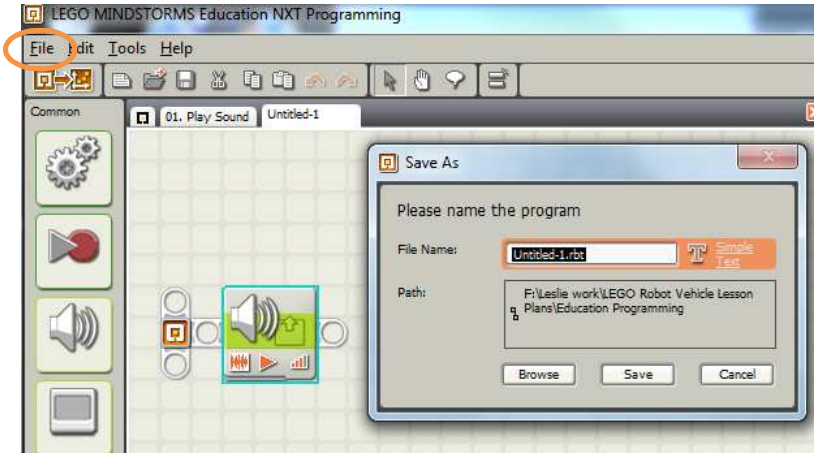
B. Open the LEGO Education Software program, NXT 2.1 Programming.

C. Using the NXT Brick

To turn on the NXT brick, press the orange button. To turn the brick off, press the gray rectangular button below the orange button and hold for 3 seconds. Use the gray arrows to school through selections on the screen.



D. Saving Files



To save a programming file for later use, click "File -> Save", name the file, and choose a location to save the files using the browse button.

E. Downloading to the Brick

Since the vehicle will be moving, it is best to download the program, disconnect the vehicle from the computer, place on the floor, and run the program from the vehicle. You do not want the vehicles rolling off of the tables.

F. Locate Downloaded Files

Press the orange button on the vehicle once to select "My Files" and again to select "Software Files".

The last file you downloaded to the vehicle will appear on the screen. Use the left and right arrow keys to move to different downloaded files. Press the orange button to select the file. Press the orange button again to run the file. Make sure your vehicle is on the floor prior to running the file.

G. Opening LEGO Education Tutorials

Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

Each training activity will have a Play Button, Building Guide and Programming Guide. The Play Button will demonstrate the activity; the Building Guide is not needed since we are using pre-assembled intelligent vehicles. The Program Guide will walk you through the programming activity.

Step 2. Training Activity 12. Detect Sound (Stop for an Emergency Vehicle)

The entire class may either watch video #6 online from the following link or view them in groups on each laptop on the desktop in Lesson 3 folder.

Move to the Right for Sirens and Lights
http://www.youtube.com/watch?v=wX2mqUpP5gY&feature=related

A. Open a new programming file by clicking "GO" in the "Start New Program" area.

B. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

C. Click on Activity 12. Detect Sound

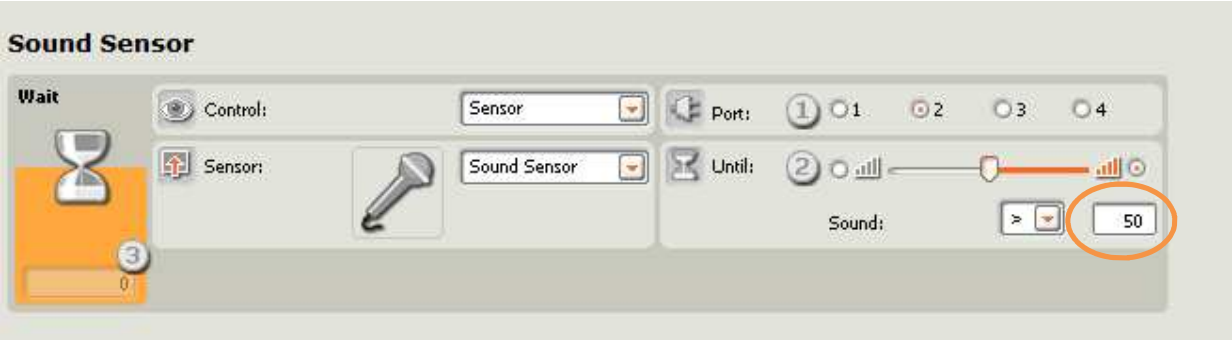
D. Scroll through the "Challenge Brief" using the right and left double arrows.

E. Click the "Programming Guide" bar and use the right and left double arrows to view the programming tutorial.

F. Complete the program as illustrated.

G. Connect the USB cable to the computer and the intelligent vehicle. Download and run the program by clicking the "Play" button in the center of the contoller.

> If the intelligent vehicle stops from other noises in the room, increase the trigger value in the "Wait" configuration panel. You may use your voice or clap to simulate a siren.



Step 3. Pull over for Emergency Vehicles

Source http://en.wikipedia.org/wiki/Image:Losangelesfiredepartmentambulance.jpg)

Program your intelligent vehicle to detect an emergency vehicle, pull off the road and stop. An emergency vehicle siren is loud and we cannot program here for a specific frequency. Students may need to try different trigger values. Watch the demonstration video #7 on each laptop or as a class entitled, "Pull over for Emergency Vehicle" in the Lesson 3 folder.

Try to program the exercise first, if you need help review the example file named, Siren Pull Over.rbt in Lesson 3 file folder.

Step 4. Follow a School Bus Route

(Source:http://commons.wikimedia.org/wiki/File:School_bus.jpg)

A school bus follows the same route every day. Students will program the intelligent vehicle to act as a bus on a route. For this exercise, the route is a 15 inches wide and 24 inches long rectangle.

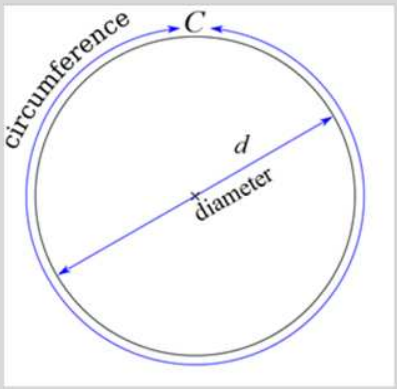
Watch the demonstration video # 8 in the Lesson 3 folder titled "Bus Route" in groups on each laptop or together as a class. Try to program the exercise first. If you need help, review the example file named "Bus Route.rbt" in Lesson 3 file folder.

MATH MOMENT!

Calculating Travel Distance

In order to program the bus to travel 15 inches, students can choose a duration of "unlimited", "degrees", "rotations", or "seconds" from the "Move" configuration panel. To provide an accurate travel distance, we will program the number of wheel rotations.

The circumference of the wheel is the length around it. One wheel rotation equals one circumference of the wheel.



Diameter of wheel is 2.25 inches

$$One\ wheel\ Rotation = Circumference = \pi \times diameter$$

What is the circumference of the intelligent vehicle wheel?

$$C = \pi \times d = 3.14 \times 2.25\ in = 7.065\ inches$$

The distanced travel in inches is the number of wheel rotations multiplied by the circumference of the wheel. But in this case we already know the distance traveled and need to calculate the number of rotations.

Therefore:

Distance traveled = circumference x wheel rotations

$$15\ inches = C \times rotations$$

Therefore to calculation the number of rotations to travel a certain distance is

$$\#\ rotations = Distance\ traveled \div C$$

$$= (15\ inches) \div (7.065\ inches) = 2.12\ rotations$$

Calculate the number of rotations to travel 24 inches.

Program the Bus Route

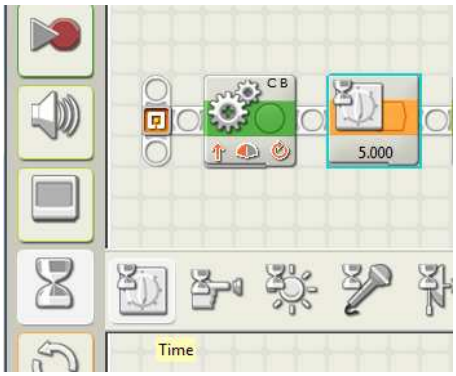
A. Open a new programming file.

B. Select the move block, drag and drop.

C. In the "Move" configuration panel, select rotations for duration and enter 2.12 rotations to travel 15 inches.

D. Reduce power to 50.

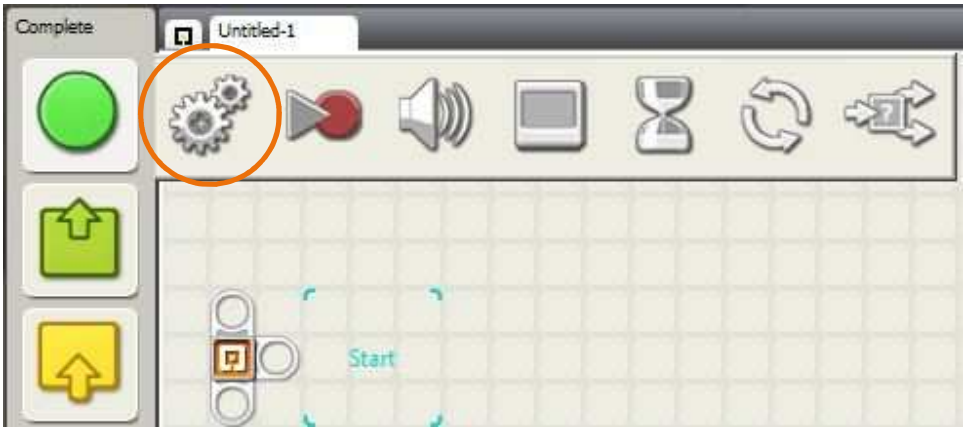
E. Insert a wait block for 5 seconds to pick up passengers.



In order to turn accurately on the black line, the right wheel (port B on brick) will need to remain stationary and the left wheel (port C on the brick) will need to rotate 350 degrees to turn the intelligent vehicle 90 degrees to the right. In order to move only one wheel the Complete Palette menu will need to be used. The complete palette menu provides more options for more complicated programming. We will only be using the move block to isolate one wheel. Once the move block for turning is finished, switch back to the Common Palette.

F. Switch to complete palette by clicking the "Complete Palette" tab.

G. Click on the "Common" button (green, round circle) and drag and drop a "move" block to the workspace.



H. Uncheck port "B" (right wheel) from the "Move" configuration panel (we only want the left wheel of port "C" to move).

I. Reduce the "Power" to 50.

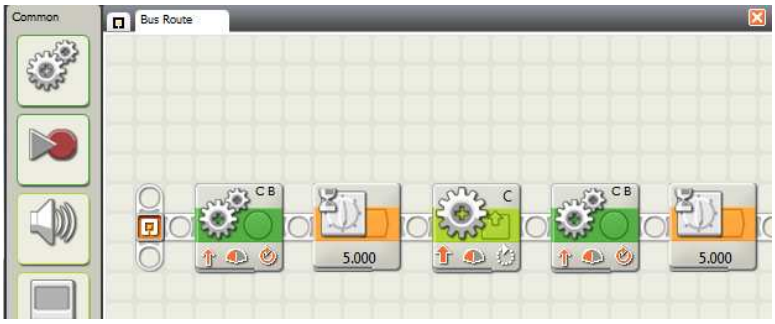
J. Set the "Duration" to 350 Degrees.

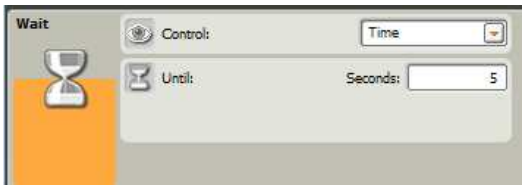
K. Switch back to the "Common Palette"

L. Calculate the number of rotations to travel 24 inches.

M. Repeat steps B – D and change the number of rotations to make the bus travel the 24 inches to the next stop.

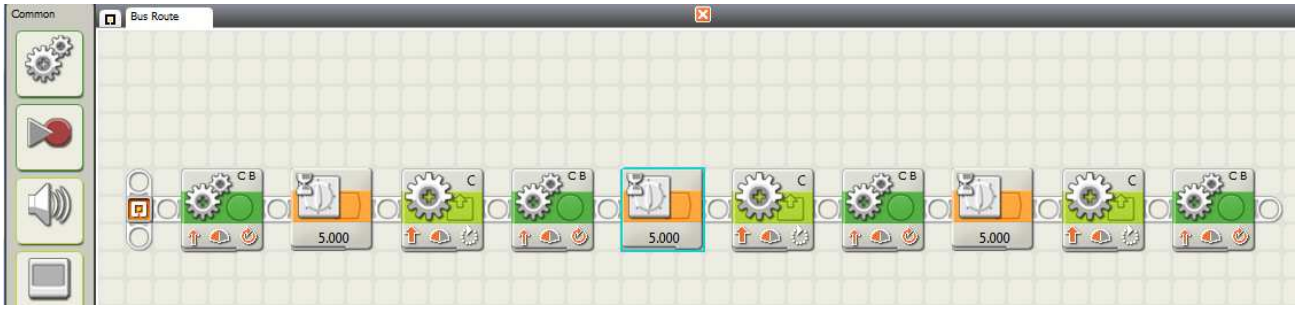
N. Program the bus to stop for 5 seconds to pick up passengers.





O. Finish the program by repeating a turn (steps F – K), travel 15 inches (steps B – D), wait 5 seconds (step E), turn (steps F – K), travel 24 inches to return to the starting point(steps B – D).

The complete bus route should look like the illustration below.



P. Once your program is complete, downloaded it to your intelligent vehicle and run on the bus route.

> Did the vehicle follow the bus route?
>
> The travel distance is based on the wheel rotations. Where should the wheel be placed at the starting point?
>
> You program to turn right pivoting on the right wheel. Should the right wheel or left wheel be on the black line?

Q. Additional Challenge

For an additional challenge (if time allows), create your own route with pedestrians and other vehicles to avoid (creating an obstacle course on the floor). Create your route on the floor using objects in the room such as a water bottle to avoid. Create a program for your route and run.

Step 5. Mini Assessment

Complete mini assessment 3.

Student Guide

Lesson 4: Follow a Route and Calculate Travel Time Exercise – Light Sensor

Agenda		
Step	***Time***	***Activity***
1	10 min	*Review Lesson 3*
2	15 min	*Training Activity 16. Detect Dark Line – Stop at an Intersection Stop Bar*
3	25 min	*Training Activity 17. Follow a Line – Follow a Route*
4	15 min	*Calculate Travel Time*
5	15 min	*Calculate travel time for a route*
6	10 min.	*Mini Assessment 4*
Total	1.5 hrs	

Step 1. Review Lesson 3

A. Complete Lesson 3 review worksheet.
Definition Review

Congestion Mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams.
Circumference – one wheel rotation or $\pi \times diameter$
Distance traveled = circumference x wheel rotations
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely.
Transportation engineer – person who works to move people and goods safely and efficiently
Traffic congestion - overcrowded or clogged roadways that prevent people from moving efficiently
Travel time – how long it takes to get from A to B

Intelligent vehicles of the future may use sensors in the pavement or roadways to maneuver. The following videos show a robot developed to automate a catalog warehouse distribution center. The robots use sensors in the floor to move products around the warehouse. Intelligent vehicles in the future may work in a similar fashion. Similar systems could be developed to distribute people and goods safely and efficiently.

http://commons.wikimedia.org/wiki/File%3APort_Santos.jpg

B. The entire class may either watch the following videos online from the following link or view them in groups on each laptop (video file #9 and #10 can be found in the Lesson 4 folder on the desktop).

Kiva Robots
http://www.youtube.com/watch?v=4kl6PhWfwjA
The Dance of the Bots
http://www.youtube.com/watch?v=Vdmtya8emMw

Step 2. Training Activity 16. Detect Dark Line (Stop at an Intersection Stop Bar)

Open the LEGO Education Software program, NXT 2.1 Programming.

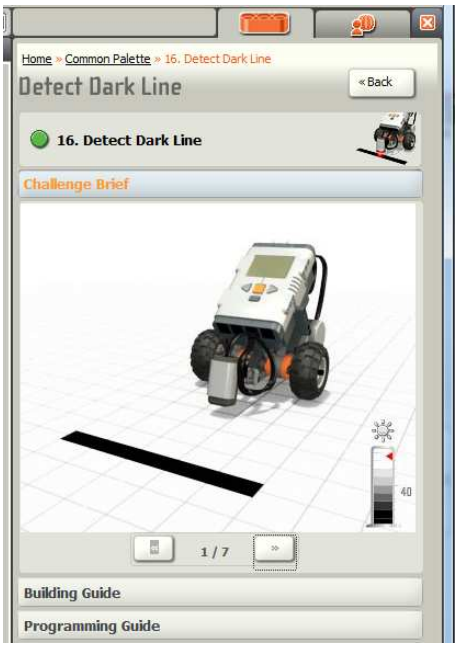
Refer to past lessons for managing memory, saving files, downloading to the brick and other basic skills.

A. Begin by starting new program file and clicking "GO" in the "Start New Program" area.

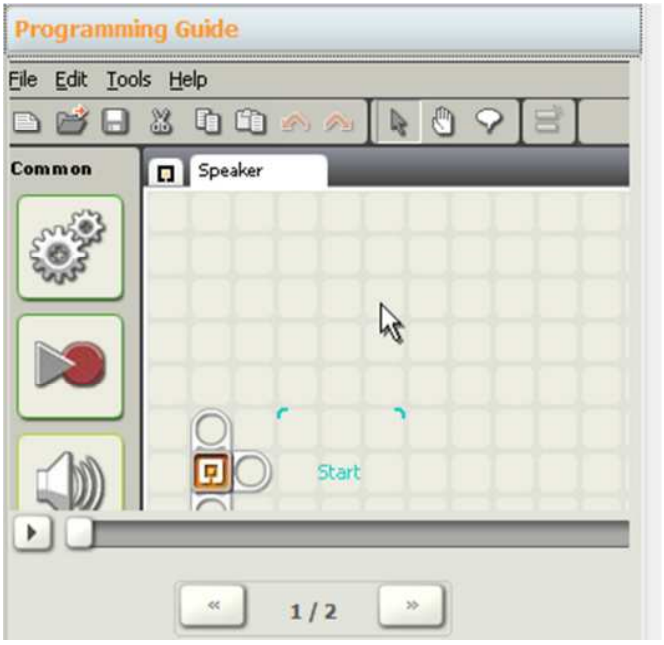
B. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

C. Click on Activity 16. Detect Dark Line

D. By default, the Challenge Brief will be shown. Click on the double arrow buttons to view the activity.



E. Click the "Programming Guide" bar (you may need to use the scroll bar on the far right to find it) and watch the tutorial that shows how to drag the desired icon(s) into the workspace.



In step 4 of the "Programming Guide", the light sensor is programed to wait to be activated by a certain intensity of light.

If your intelligent vehicle is running on a surface of any color other than white before detecting the black line, an adjustment to the trigger value may be needed. The orange arrow on the left above is the feedback box which displays the current light reading (0-100%). You can use it to try out different trigger values.

Select the left radio button (step 6 of tutorial) to program the block with light levels lower than the trigger value. If you check the "Generated Light" checkbox, the light sensor will turn on its own small light source and detect this light if it is reflected back to it.

Complete the program as illustrated to make the intelligent vehicle stop at an intersection stop bar (represented by the black tape).

F. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "Download" button in the bottom left corner of the controller.

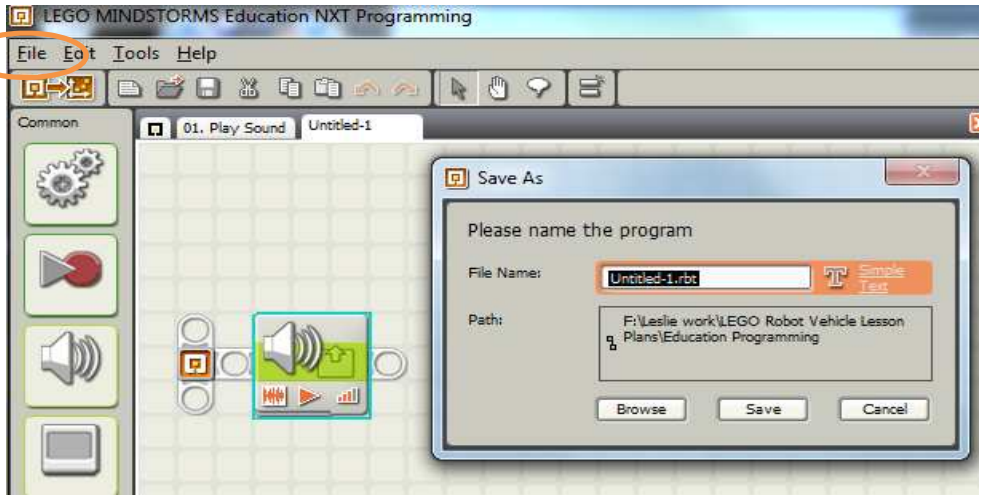
G. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

H. Place the vehicle a short distance from the stop bar (black tape) and run the program.

> The last file you downloaded to the vehicle will appear on the screen. Use the left and right arrow keys to move to different downloaded files. Press the orange button to select the file, press the orange button again to run the file. Make sure your vehicle is on the floor prior to running the file.

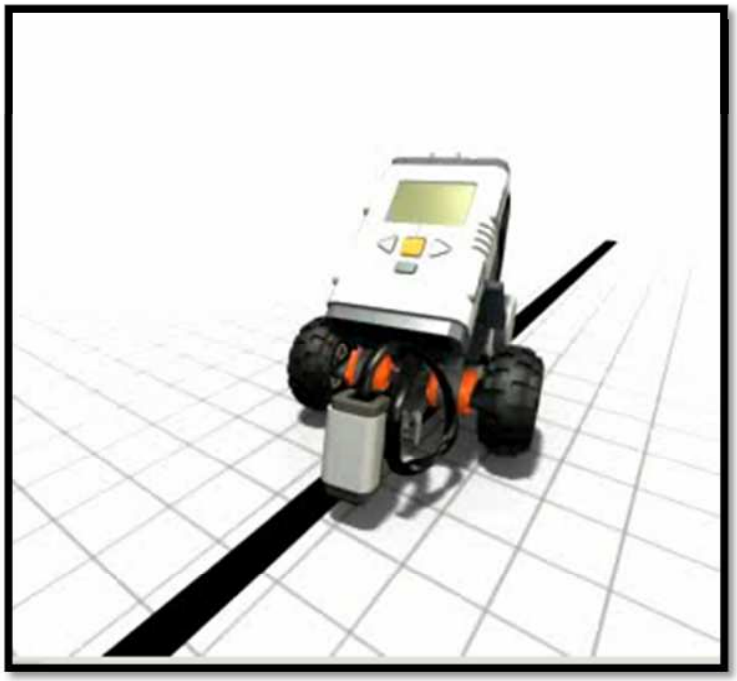
I. Press the orange button on the vehicle once to select "My Files" and again to select "Software Files".

J. To save your programming file to use again, click "File -> Save", name the file and find the location to save files using the browse button. Teachers may want to pre-determine a naming convention and location for students to save files.



To return to the Common Palette, click the "Back" button in the upper right hand corner of your window.

Step 3. Training Activity 17. Follow a Line (follow a route)



A. Open a new programming file.

B. Click on the back button in the Common Palette

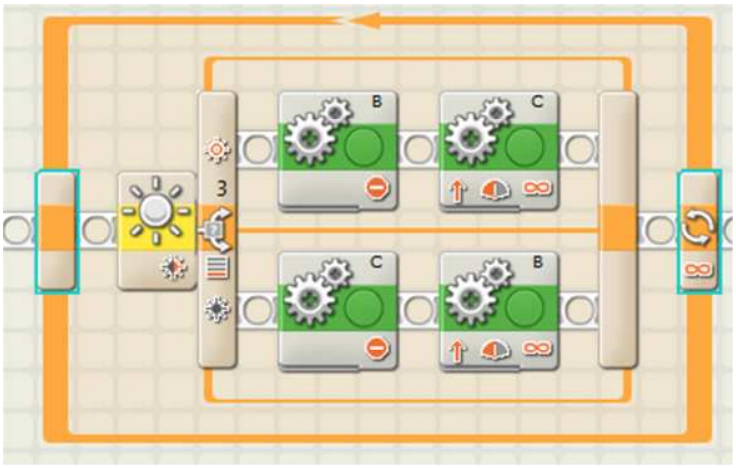
C. Click on Activity 17. Follow a Line in the Common Palette

D. Complete the program as illustrated, to make the intelligent vehicle follow a route (a black line.)

Loop Blocks and Switches

Loop block – any programming blocks inside the loop block will repeat in a loop (in this exercise, forever).

Switch block – in this program the light sensor switch block is used. If the light sensor detects a dark line, motor C (left wheel) will stop and motor B (right wheel) moves forward. If the light sensor then detects a lighter road surface the right wheel stops and left wheel moves forward.



For additional information on the loop and switch block, see the help tab

E. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "download" button in the bottom left corner of the controller.

F. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

G. Place the vehicle at the beginning of the black line

H. Run the program from the NXT brick (refer to Step 2, letter H for help).

I. Save the program for use in Step 5 (see Step 2, letter J for help).

Step 4. Calculate Travel Time

MATH MOMENT!

Calculating Travel Time

Have you ever used a mapping application to find out how long it will take you to drive from one destination to another?

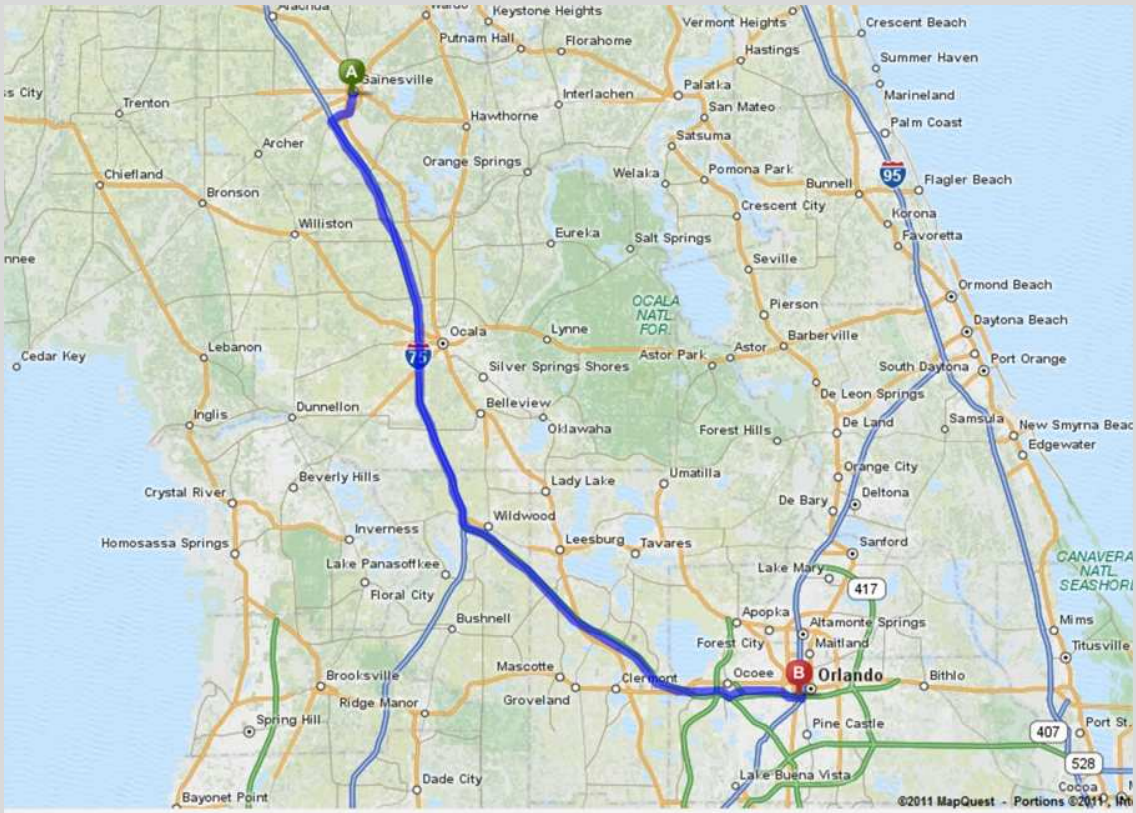
If you travel from Gainesville Florida to Orlando Florida, the distance is 120 miles. How long will it take to drive 120 miles (or what is the travel time)? Travel time is a function of distance and speed.

$$travel\ time\ (hours) = \frac{distance(miles)}{speed\ (miles\ per\ hour)}$$

Therefore if you travel at a constant 60 miles per hour,

$$travel\ time\ (hours) = \frac{120(miles)}{60\ (miles\ per\ hour)}$$

$$travel\ time = 2\ hours$$



Step 5. Calculate Travel Time for a Route

A. Using the five foot long route of tape on the floor, calculate the time for the intelligent vehicle to travel from one end to the other.

$$travel\ time\ (seconds) = \frac{distance(feet)}{speed\ (feet\ per\ second)}$$

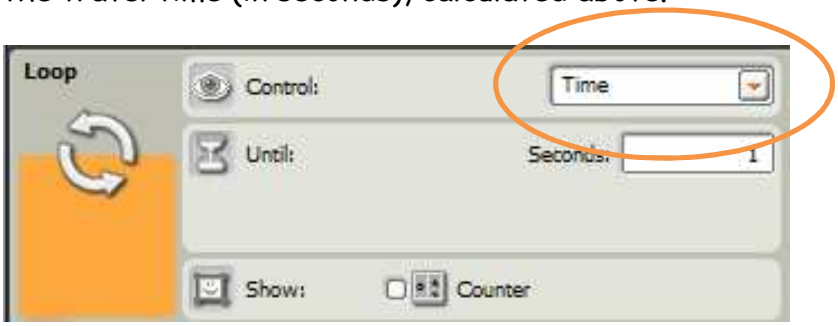
The constant speed for the intelligent vehicle following a route at 50% motor power (fully charged battery) is 0.19 feet per second.

$$travel\ time\ (seconds) = \frac{5(feet)}{.19\ (feet\ per\ second)}$$

travel time = 26.3 seconds

B. Use the program from Step 3 to make the intelligent vehicle stop after the calculated travel time.

C. Click on the existing "Loop Block". Change the loop control from forever to time, insert the travel time (in seconds), calculated above.



D. Download your program to the NXT brick.

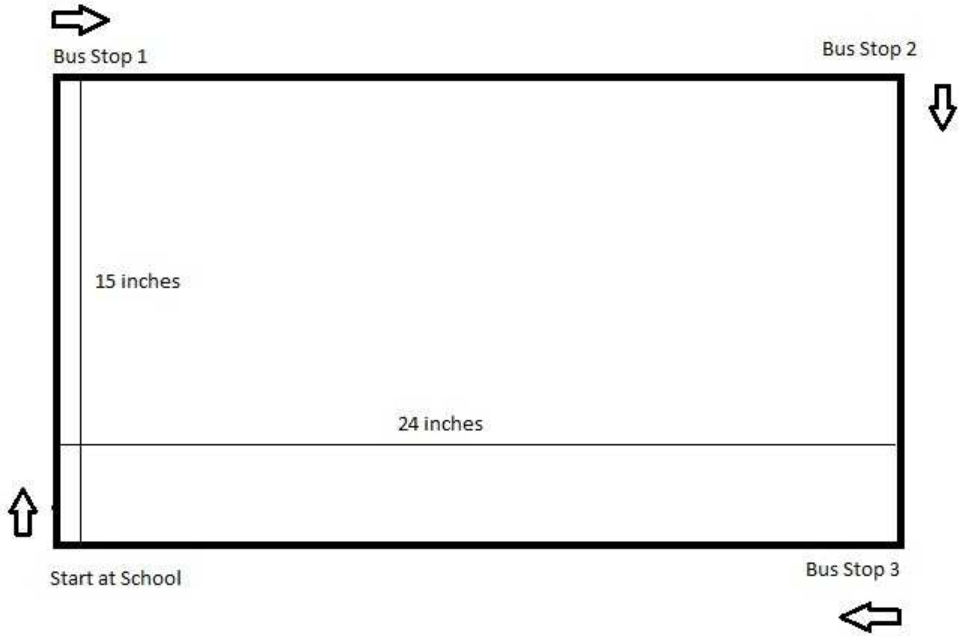
E. Place your intelligent vehicle on the floor at the one end of the five feet of roadway (black tape).

F. Run the program (refer to Step 2, letter H for help).

****Did your intelligent vehicle stop after 5 feet at the end of the roadway (black tape)?****

G. Additional Challenge

For an additional challenge (if time allows), calculate the travel time for the bus route in Lesson 3.



Run the program and time the route using a timer or stopwatch to test your calculations. Do the travel time measurement and calculations match? Why not?

Was your speed constant? (Answer: No, the acceleration and deceleration over a short distance made the average speed inaccurate.)

Step 6. Mini Assessment

Complete mini assessment 4.

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Student Guide

Lesson 5: Pedestrian and Vehicle Detection Exercise – Ultrasonic Sensor

Agenda		
Step	***Time***	***Activity***
1	10 min	*Review Lesson 4*
2	20 min	Training Activity 14 Detect Distance – Stop for a Pedestrian
3	35 min	*Stop for a Pedestrian and then continue*
4	10 min	*Mini Assessment 5*
5	15 min.	*Post Test Questionnaire*
Total	1.5 hrs	

Step 1. Review Lesson 4

A. Complete Lesson 4 review worksheet.

Review definitions:
Circumference – one wheel rotation or $\pi \times diameter$
Congestion mitigation - providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams.
Distance traveled = circumference x wheel rotations
Engineer – person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS) - using technology to make the roadways in a city or town operate more efficiently and safely.
Transportation engineer – person who works to move people and goods safely and efficiently
Traffic congestion - overcrowded or clogged roadways that prevent people from moving efficiently
Travel time – how long it takes to get from A to B

Step 2. Training Activity 14. Detect Distance (Stop for a Pedestrian)

The entire class may either watch video #11 online from the following link or view them in groups on their laptop on the desktop in Lesson 3 folder.

Video #11 Volvo Pedestrian Detection

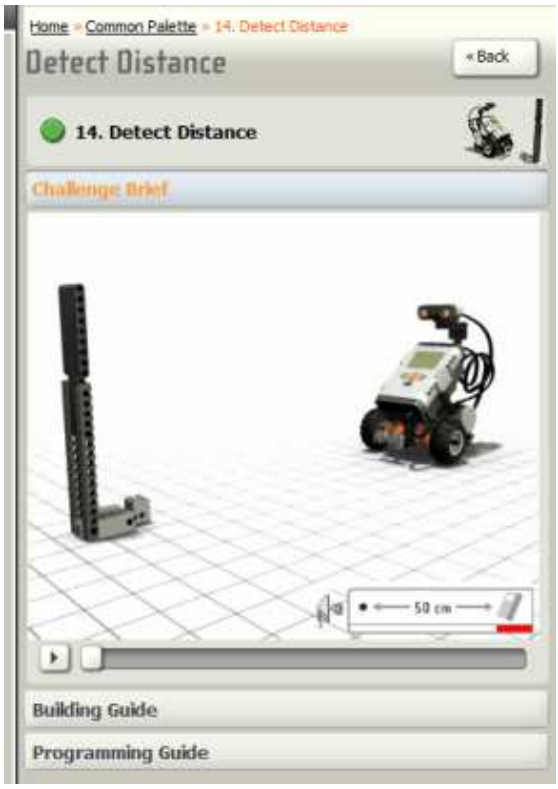
http://www.youtube.com/watch?v=wPUGwbpfVhQ

A. Open the LEGO Education Software program, NXT 2.1 Programming.

B. Begin by starting new program file by clicking "GO" in the "Start New Program" area.

C. Click on "Common Palette" on the top right corner of LEGO Education Software screen to access the training activities.

D. Click on Training Activity 14. Detect Distance



E. By default, the Challenge Brief will be shown. Click on the Play Button to view the activity.

F. Click the "Programming Guide" bar (you may need to use the scroll bar on the far right to find it) and watch the tutorial that shows how to drag the desired icon(s) into the proper window.

G. Complete the program as illustrated to make the intelligent vehicle stop short of the "pedestrian".

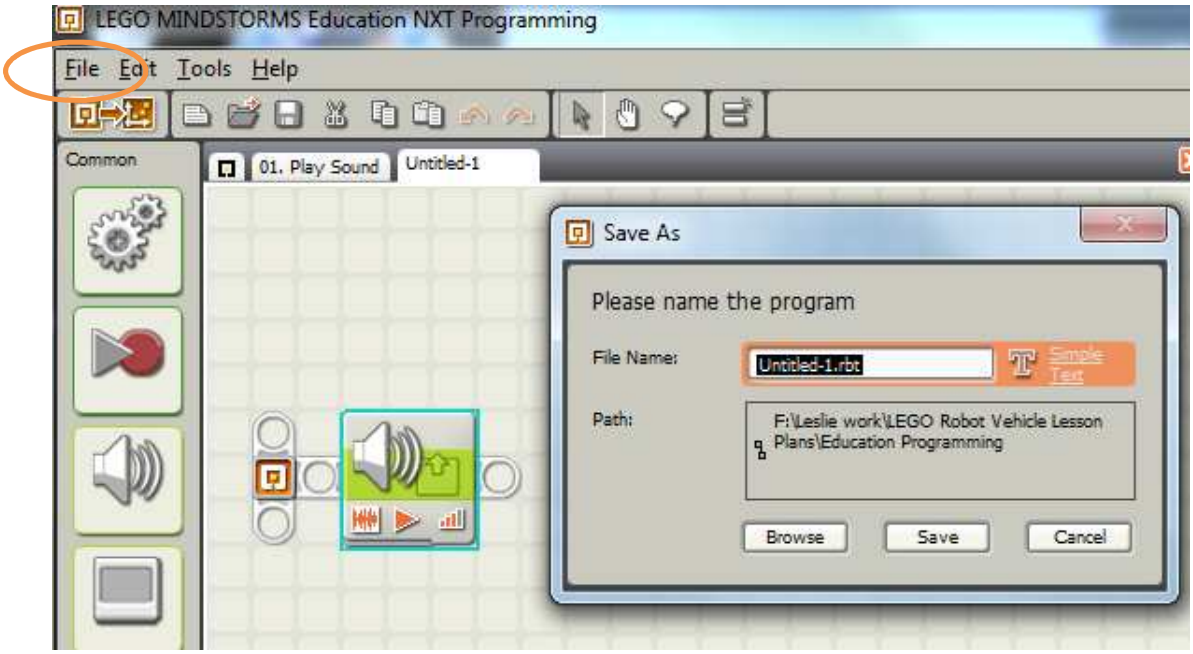
H. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "download" button in the bottom left corner of the controller.

I. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

J. Place the vehicle in front of the "pedestrian" and run the program from the intelligent vehicle. Rather than using a tower structure like the picture in the Challenge Brief, you may use your hand, a doll, or a LEGO structure to simulate a pedestrian in the path of the vehicle.

In the video the car uses a camera and radar (electromagnetic waves) system. Our intelligent vehicle uses an ultrasonic (sound waves) sensor. The ultrasonic sensor sends out a sound wave. When the wave hits an object, it is reflected back to the sensor. The ultrasonic sensor calculates the distance of the object based on the time it takes for the wave to return to the sensor.

K. To save your programming file to use again, click "File -> Save", name the file and find the location to save files using the browse button. Teachers may want to pre-determine a naming convention and location for students to save files.



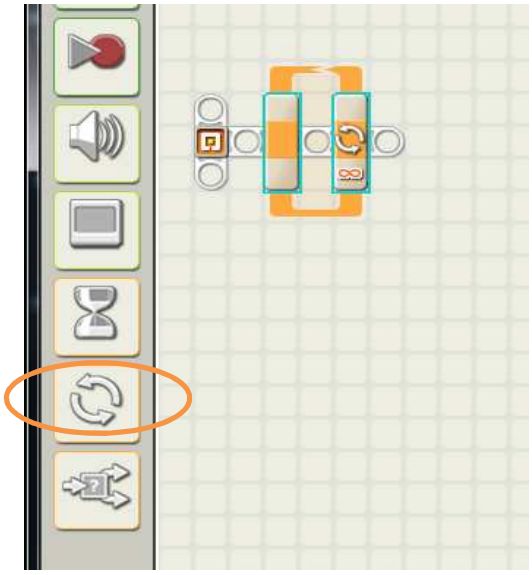
To return to the Common Palette, click the "Back" button in the upper right hand corner of your window.

Step 3. Stop for a Pedestrian and then Continue

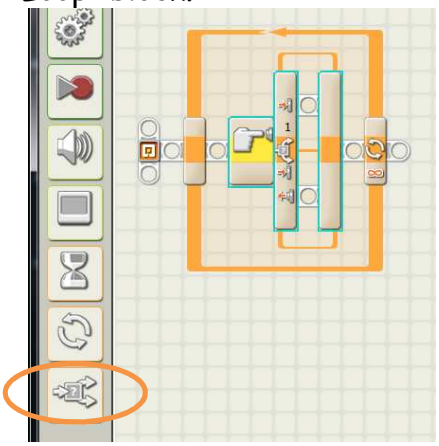
Challenge the students to program the vehicle to stop for a pedestrian and then continue when the pedestrian moves out of the way without using the following tutorial.

A. Open a new programming file.

B. Drag a "Loop" block onto the workspace.

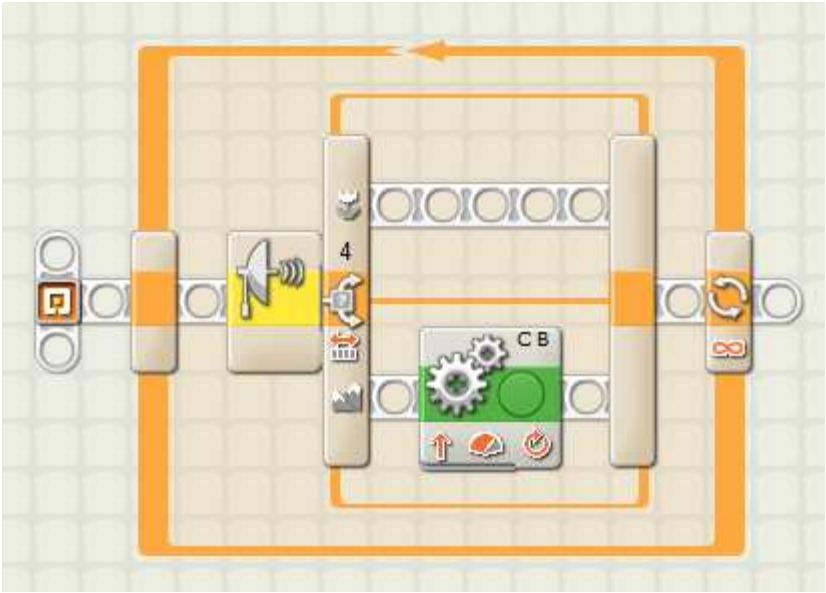


C. Drop a "Switch" block inside the "Loop" block.



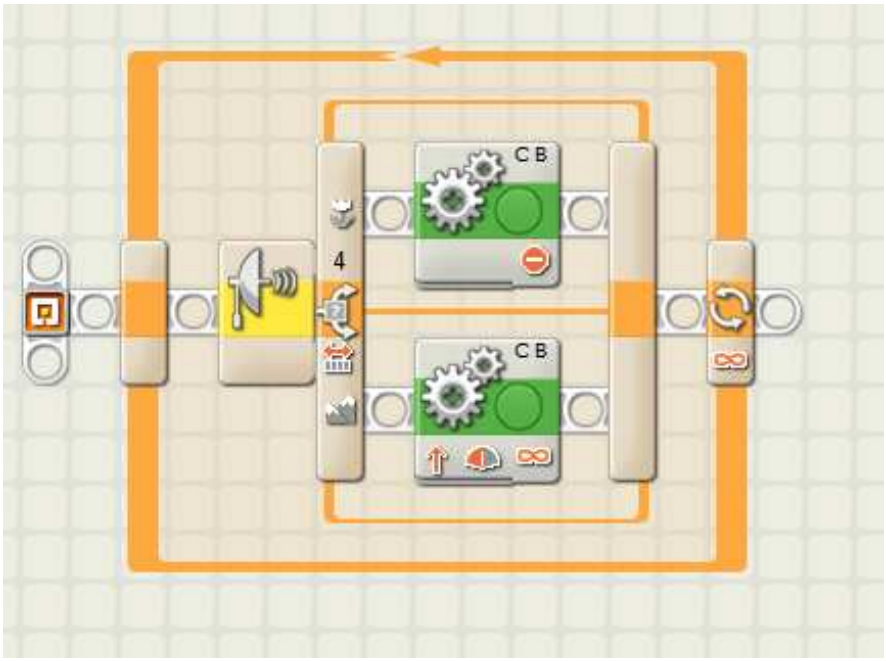
D. Change the settings in the "Switch" block configuration panel from the default ("Touch Sensor") to "Ultrasonic Sensor" and set the "Distance" to 15 inches.

E. Drop a "Move" block on the bottom row of the "Ultrasonic Sensor" "Switch" block.



F. In the "Move" configuration panel, change the "Power" from 75 to 50.

G. Drop another "Move" block on the top row of the "Ultrasonic Sensor" "Switch" block.



H. Change the "Direction" to "Stop" in the "Move" configuration panel.

I. Connect the USB cable to the computer and the intelligent vehicle. Download the program by clicking the "download" button in the bottom left corner of the controller.

J. Disconnect the vehicle from the computer and place on the floor (you do not want the vehicles rolling off of the table).

K. Place the vehicle at a starting point greater than 15 inches away from an object.

L. Run the program from the NXT brick.

Did the vehicle stop 15 inches away from the object? Move the object and the vehicle should begin to move forward again.

M. Place another object in the vehicles path.

Did the vehicle stop 15 inches away from the object?

N. Save the program.

O. Additional Challenge 1

For an additional challenge, program the intelligent vehicle similarly to the video. Add a sound and display a warning for the driver when a pedestrian is at a pre-determined distance and then have the vehicle stop when the pedestrian is closer.

Additional Challenge 2

Which student team can get as close as possible to another vehicle without touching it? Use any available object to simulate the other vehicle as long as the object is tall enough to be sensed by the ultrasonic sensor. A wall can also be used.

Step 4. Mini Assessment

Hand out mini assessment 5 for the students to complete.

Lesson Reviews

Lesson 1 Review

How many different types of vehicles do you see in the above picture?

Can you name any other types of transportation?

What function do these vehicles serve?

What would happen if there were too many vehicles in one area?

List some problems that could occur.

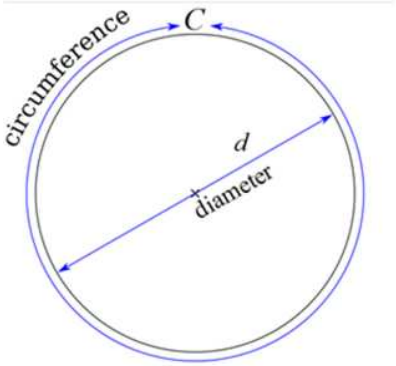
Lesson 2 Review

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

What features would you want your intelligent vehicle of the future have to mitigate congestion?

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car.

Lesson 3 Review



Diameter of wheel is 2.25 in

$$One\ wheel\ Rotation = Circumference = \pi \times diameter$$

What is the circumference of the intelligent vehicle wheel?

$$C = \pi\, x\, d =$$

Distance traveled = circumference x wheel rotations

If you program you intelligent vehicle to move 3 rotations, what is the distance it will travel?

Lesson 4 Review

Match the words with their definition.

Circumference	circumference x wheel rotations
Congestion mitigation	person who works to move people and goods safely and efficiently
Distance traveled	one wheel rotation or ∏x diameter
Engineer	overcrowded or clogged roadways that prevent people from moving efficiently
Intelligent Transportation Systems (ITS)	how long it takes to get from A to B
Transportation Engineer	providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Traffic congestion	person who applies science, math and creativity to solve problems
Travel time	using technology to make the roadways in a city or town operate more efficiently and safely

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Mini Assessments

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

Write down 3 examples of negative effects of traffic congestion.

What does it mean to "mitigate congestion"?

Mini Assessment 2

An engineer applies _____, _____ and _____ to solve problems.

Traffic Engineer's work to move _____ and _____ efficiently.

ITS stands for _____.

What else would you want to program your intelligent vehicle to say or display that could reduce traffic congestions?

Mini Assessment 3

Give 3 examples of how can an intelligent school bus reduce roadway congestion?

How would an emergency vehicle detector improve roadway safety?

If so, why?

If not, why not?

Mini Assessment 4

A bus driver is driving students to school. It takes her 1 hour to cover the whole bus route (which is 15 miles long). What is the bus' average speed?

If this same bus added another stop to the route that was 5 miles away but kept the same average speed, how long would the bus route now take to complete?

SHOW YOUR THINKING with drawings or equations.

Mini Assessment 5

List 2 things that can cause congestion. For each of those things, list how an ultrasonic sensor might be able to mitigate (or prevent) that congestion.

Cause of Congestion	Way to use ultrasonic sensor to mitigate
1.	
2.	

Questionnaires

LEGO® Robot Intelligent Vehicle Lesson Plans
An Introduction to Transportation Engineering

Pre-Course Questionnaire

I have a computer at home. ☐ Yes ☐ No
I like or used to like playing with LEGOs. ☐ Yes ☐ No

What grade are you in? _____

Instructions: Read the sentences carefully.
Circle one best answer for each sentence.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
5	4	3	2	1	1. I like math.
5	4	3	2	1	2. I like science.
5	4	3	2	1	3. I can program a LEGO Mindstorm Robot.
5	4	3	2	1	4. I know what a transportation engineer does.
5	4	3	2	1	5. I understand what traffic congestion is.
5	4	3	2	1	6. I will consider going to college and becoming an engineer.
5	4	3	2	1	7. I will study hard at math and science.

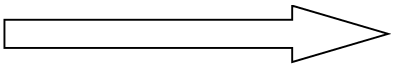
LEGO® Robot Intelligent Vehicle Lesson Plans
An Introduction to Transportation Engineering

Post-Course Questionnaire

Instructions: Read the sentences carefully.
Circle one best answer for each sentence.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
5	4	3	2	1	1. I like math.
5	4	3	2	1	2. I like science.
5	4	3	2	1	3. I can program a LEGO Mindstorm Robot.
5	4	3	2	1	4. I know what a transportation engineer does.
5	4	3	2	1	5. I understand what traffic congestion is.
5	4	3	2	1	6. I will consider going to college and becoming an engineer.
5	4	3	2	1	7. I will study hard at math and science.
5	4	3	2	1	8. Learning to program the robot by thinking logically will help me solve other problems.
5	4	3	2	1	9. The Lego Mindstorm Robot is easy to use.
5	4	3	2	1	10. The course helped me understand the use of math, science, and technology.
5	4	3	2	1	11. Learning about a transportation engineer was interesting.
5	4	3	2	1	12. I had enough time to complete the exercises.
5	4	3	2	1	13. The Lego robotics lessons were hard.
5	4	3	2	1	14. The Lego robotics lessons were fun.
5	4	3	2	1	15. I would like to take another robotics course.

Please read and answer the questions on the back.



Please write a brief answer to the next four questions.

1. What I will remember the most about this Introduction to Transportation Engineering Course is_____.

2. What is an engineer?

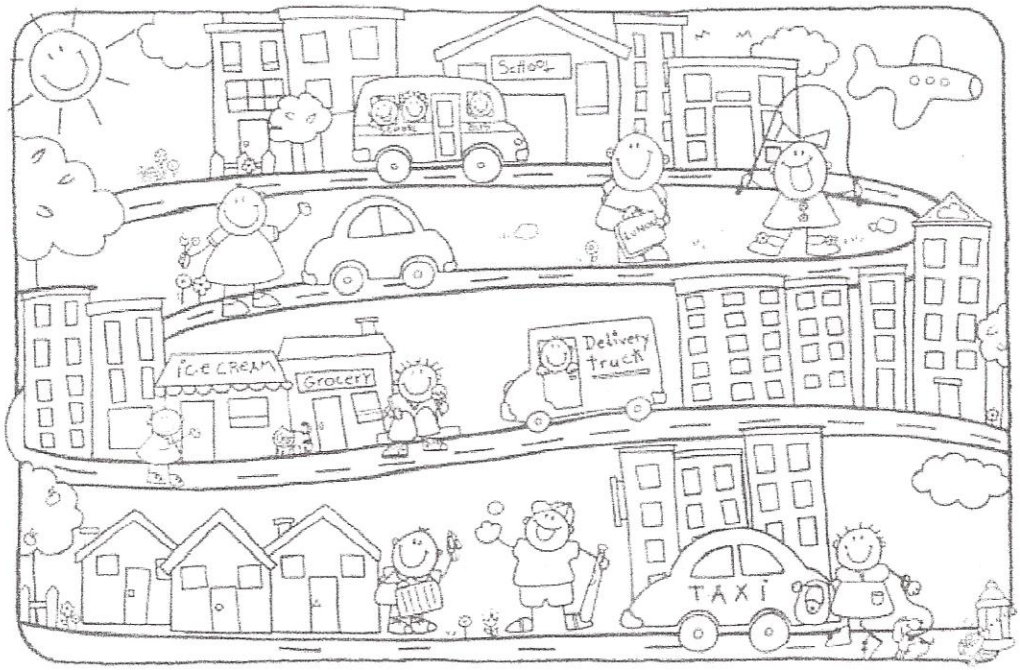
3. What would you like about being a transportation engineer?

4. What would you NOT like about being a transportation engineer?

Appendix C

Lesson Reviews Course Material

Exercise 1.



How many different types of vehicles do you see in the above picture?

5 vehicles

Can you name any other types of transportation?

Walking, biking, skipping, tricycle, jogging

What function do these vehicles serve?

To move people from one place to another

What would happen if there were too many vehicles in one area?

There would be a jam and no one would move.

List some problems that could occur.

There could be a jam, and angry drivers.

Exercise 1.

How many different types of vehicles do you see in the above picture?

Car, Truck, Airplane, Bus

Can you name any other types of transportation?

Boat, Walking, biking, tricycle

What function do these vehicles serve?

The car can carry people and drive. The Bus is the expanded version of the car
The Truck can carry cargo or goods.
The Airplane can carry people but in the air.

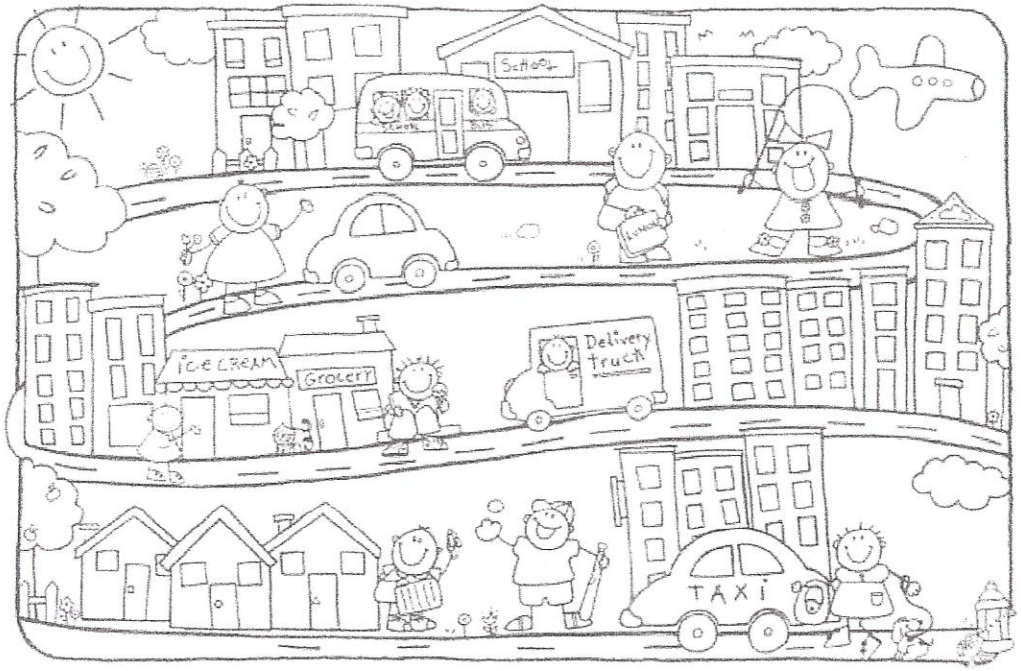
What would happen if there were too many vehicles in one area?

Traffic would slow cars down

List some problems that could occur.

Speeding and crashing

Exercise 1.



How many different types of vehicles do you see in the above picture?

5

Can you name any other types of transportation?

walking, biking, motorcycle

What function do these vehicles serve?

To move more people from one place to another

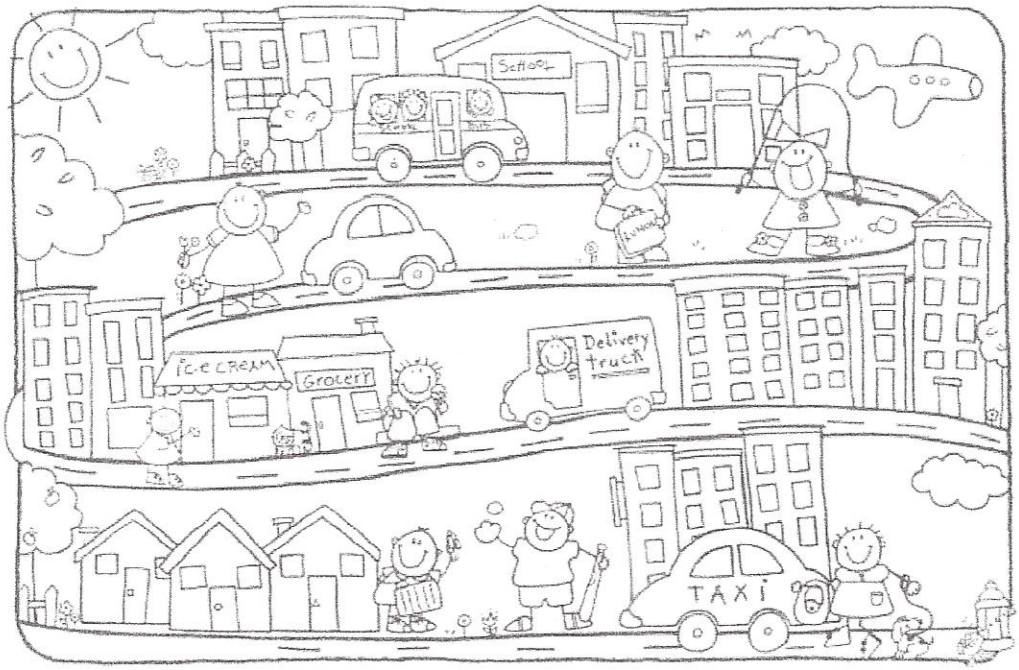
What would happen if there were too many vehicles in one area?

There will be a jam

List some problems that could occur.

crashes

Exercise 1.



How many different types of vehicles do you see in the above picture?

5

Can you name any other types of transportation?

Bike, Unicycle, tricycle, train

What function do these vehicles serve?

transportation

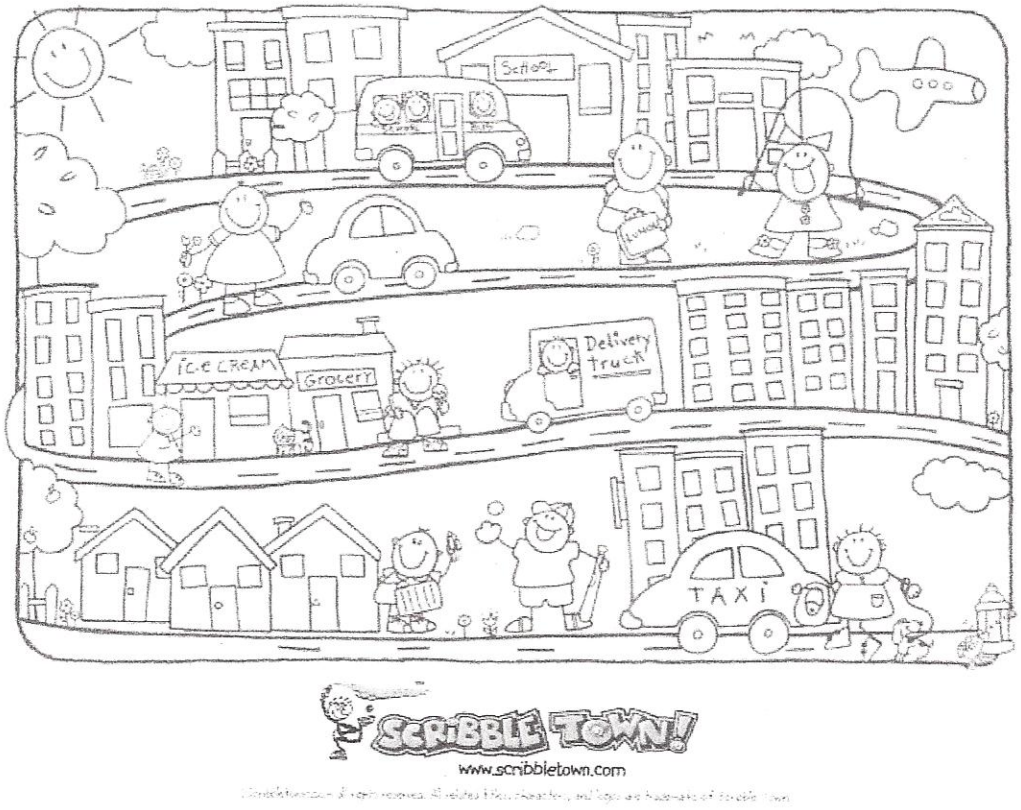
What would happen if there were too many vehicles in one area?

trafic jam

List some problems that could occur.

crashes, trafic jam,

Exercise 1.



How many different types of vehicles do you see in the above picture?

5

Can you name any other types of transportation?

boat

What function do these vehicles serve?

transporting people /or goods

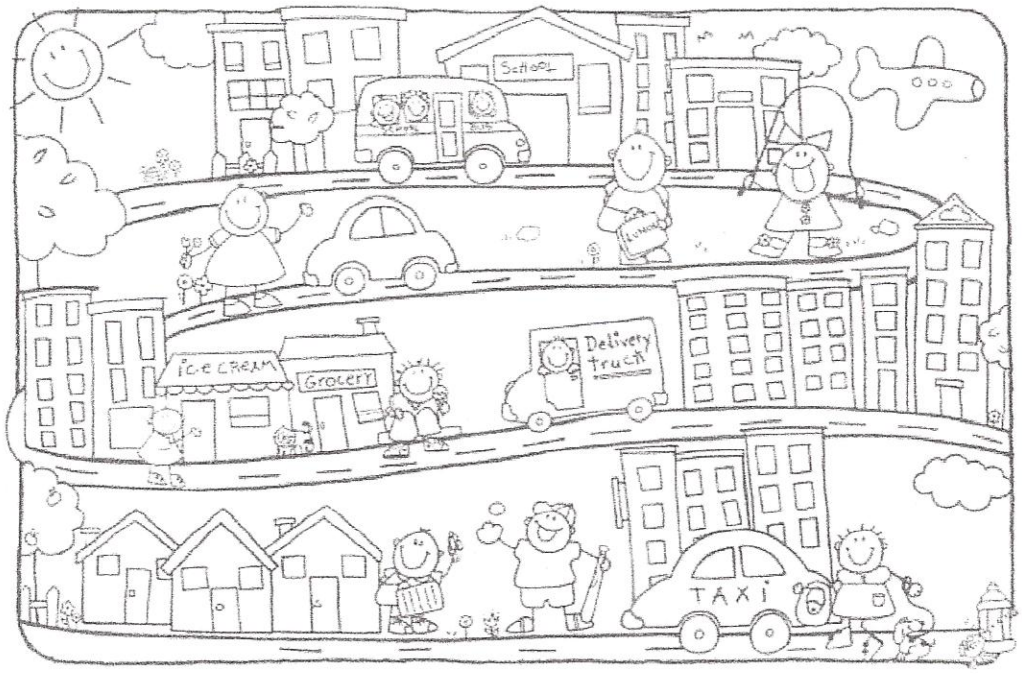
What would happen if there were too many vehicles in one area?

traffic jam

List some problems that could occur.

cars crash

Exercise 1.



How many different types of vehicles do you see in the above picture?

5

Can you name any other types of transportation?

walking, tricycle, bicycle, unicycle

What function do these vehicles serve?

To move a thing from Point A to Point B

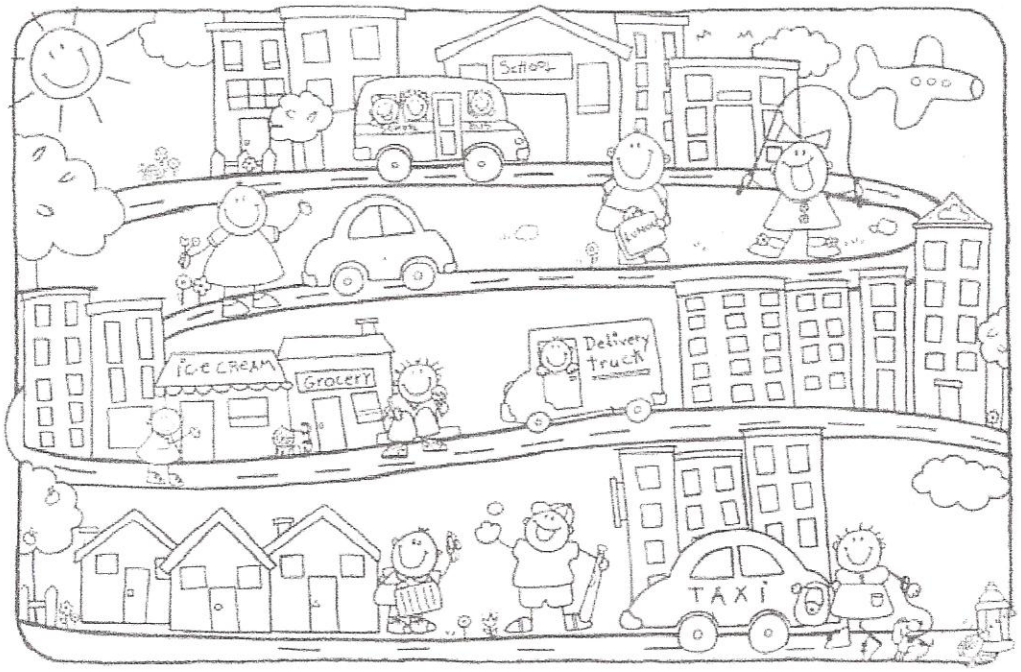
What would happen if there were too many vehicles in one area?

There will be traffic congestion

List some problems that could occur.

- road rage
- pollution
- waste of fuel

Exercise 1.



How many different types of vehicles do you see in the above picture?

4

Can you name any other types of transportation?

Train

What function do these vehicles serve?

transportation

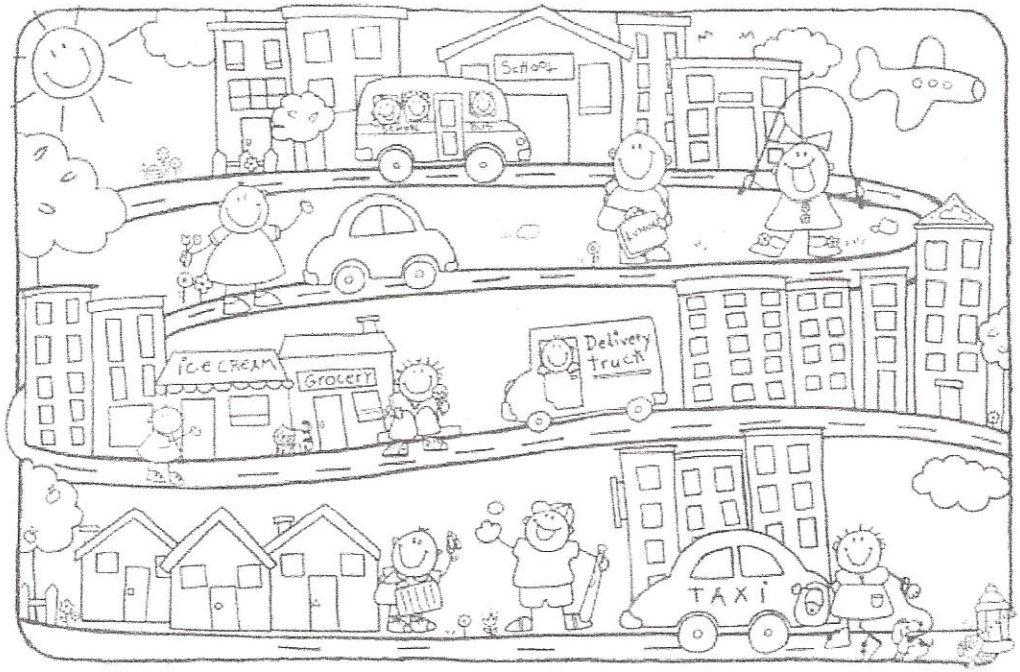
What would happen if there were too many vehicles in one area?

Obstacle Congestion

List some problems that could occur.

Crash

Exercise 1.



How many different types of vehicles do you see in the above picture?

taxi cab, car, truck, mini, 5

Can you name any other types of transportation?

Train, boats, hovercraft, bike, helicopter

What function do these vehicles serve?

To transport fforom place to place.

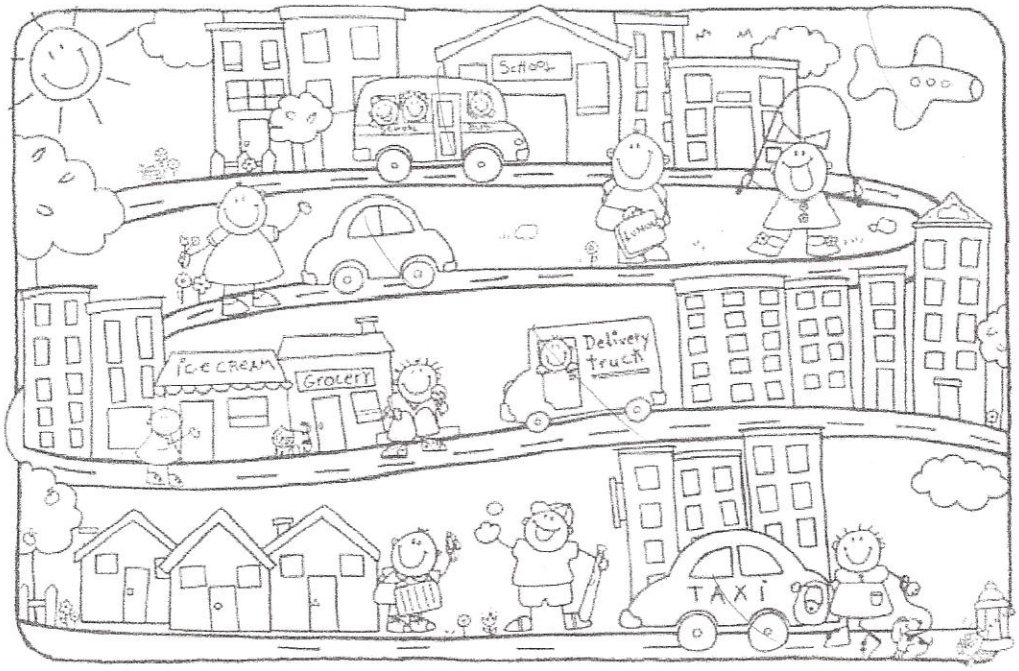
What would happen if there were too many vehicles in one area?

Trafic conjeston, you would do nothing, crashes

List some problems that could occur.

Lose gas, be late for emergency, crashes

Exercise 1.



How many different types of vehicles do you see in the above picture?

(5) taxi, delivery truck, car, airplane, school bus

Can you name any other types of transportation?

trains, bicycle, helicopter, boats,

What function do these vehicles serve?

They all take people to places

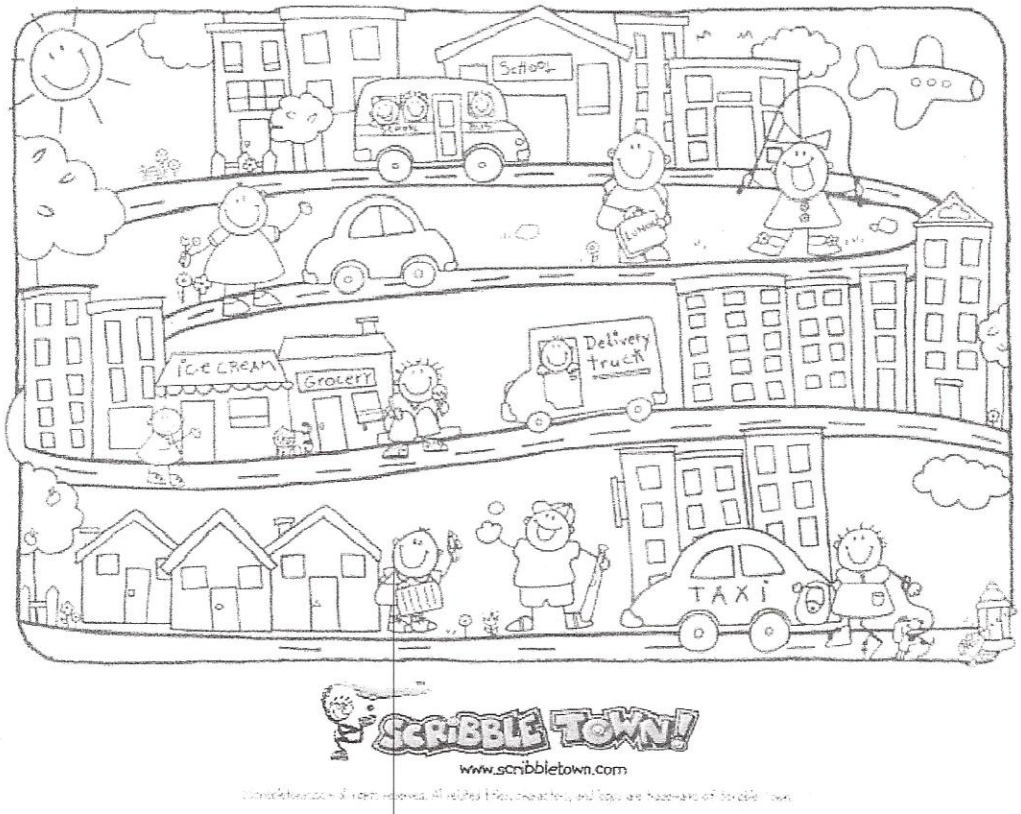
What would happen if there were too many vehicles in one area?

traffic congestion, crashes, waste of time

List some problems that could occur.

Lose gas, be late for emergency

Exercise 1.



How many different types of vehicles do you see in the above picture?

5

Can you name any other types of transportation?

Hovercraft, rocket, bike, train, boat

What function do these vehicles serve?

They help you get from one place to another

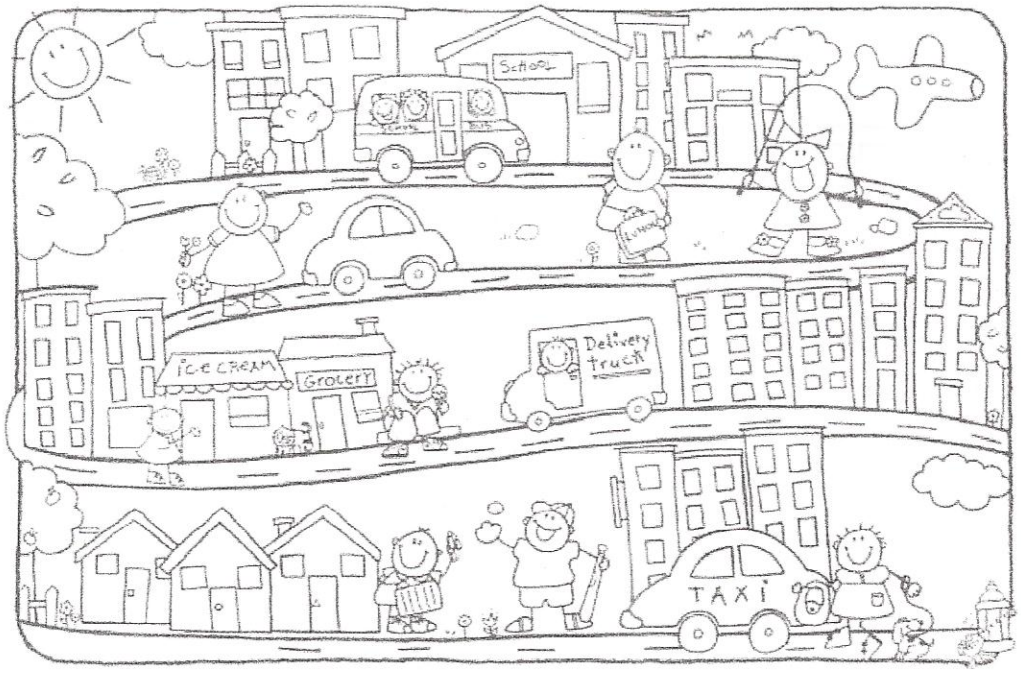
What would happen if there were too many vehicles in one area?

There would be traffic jams,

List some problems that could occur.

accidents, angery drivers, more air pollution, wasted gas

Exercise 1.



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www.scribbletown.com

How many different types of vehicles do you see in the above picture?

6

Can you name any other types of transportation?

escalator

What function do these vehicles serve?

transportation

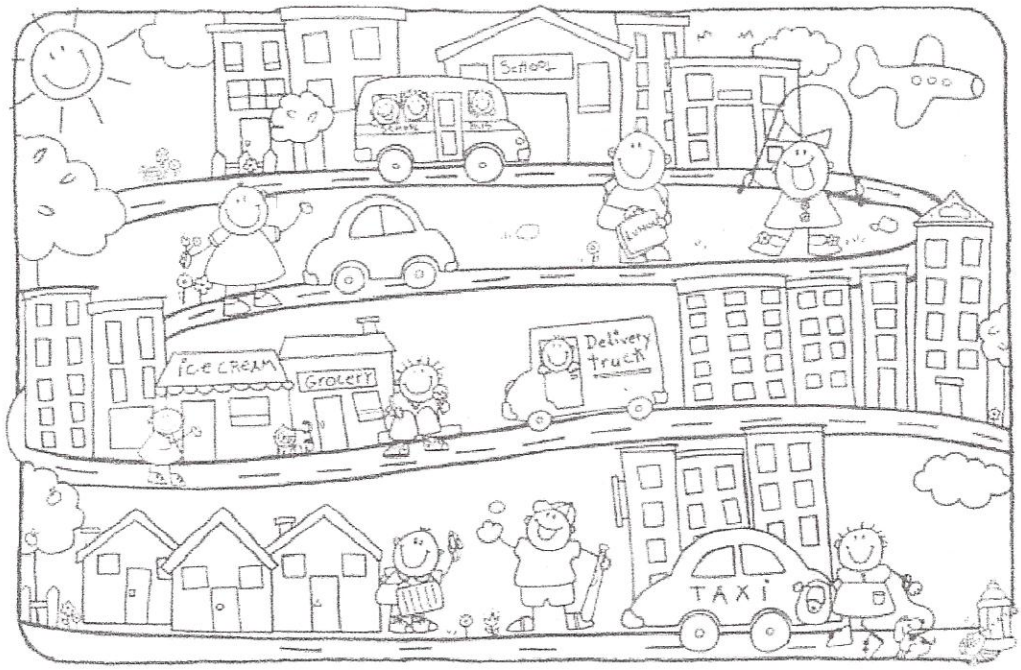
What would happen if there were too many vehicles in one area?

congestion

List some problems that could occur.

tardiness frustration crashes

Exercise 1.



How many different types of vehicles do you see in the above picture?

5

Can you name any other types of transportation?

Walking

What function do these vehicles serve?

to get from one place to another

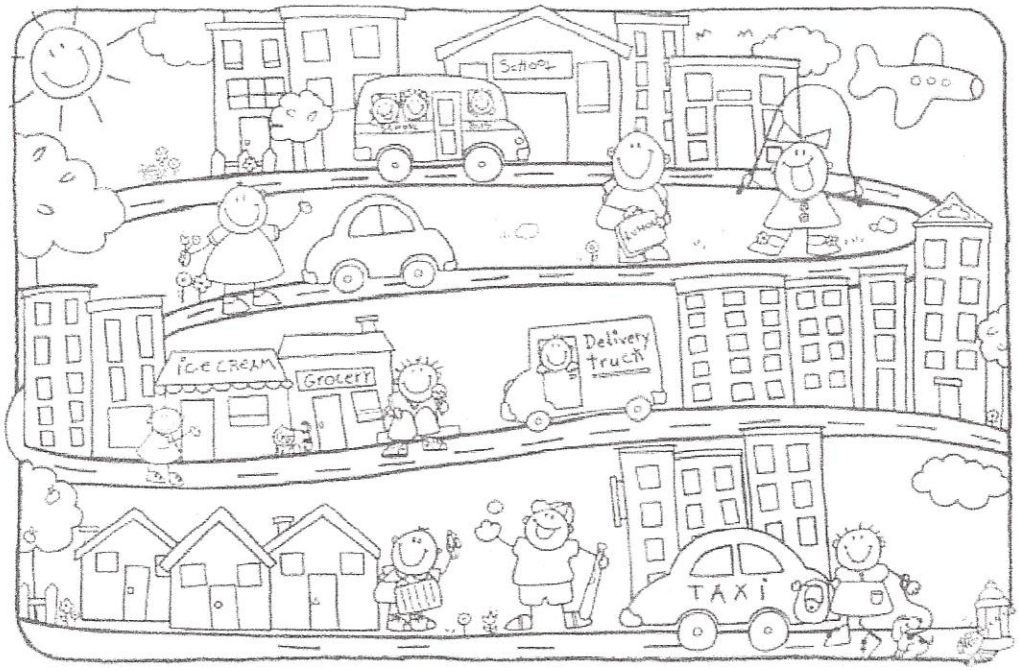
What would happen if there were too many vehicles in one area?

there would be a traffic jam

List some problems that could occur.

crashes, fatalitys, damage, slowed down, waste of time energy

Exercise 1.



How many different types of vehicles do you see in the above picture?

4

Can you name any other types of transportation?

train, boat, motercycle, walking

What function do these vehicles serve?

They transport people

What would happen if there were too many vehicles in one area?

ther would be confusian and traffic

List some problems that could occur.

you cold be late to work / An ambulance might not make it to the hospital on time

1

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? It would need to be able to sense color, sound, and objects. It would also need to know how to follow directions and stay on the charted course.

What features would you want your intelligent vehicle of the future have to mitigate congestion? Motion sensors, wings, sound detectors.

5/11/24

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. GPS, foot warmer, smart screen to warn you of oncoming cars, warning sounds

2

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? The intelligent vehicle should be able to tell where traffic jams and show it on a map which shows traffic

What features would you want your intelligent vehicle of the future have to mitigate congestion?

to have a traffic map

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. sense things in front of it

3

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? It would have GPS to show alternative routes. Also it will show traffic conditions. Finally it will detect objects near the vehicle.

What features would you want your intelligent vehicle of the future have to mitigate congestion? Send messages of events that will affect you, like an ambulence is approching.

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. radio, sensors, GPS

4

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

Sense lights, colors, and objects, send messages to other cars, to stop, or warn of coming objects.

What features would you want your intelligent vehicle of the future have to mitigate congestion?

motion sensors, gas savers, talking messages, project pictures on the screen to warn you.

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car.

Motion sensors, cops(built in), talking (warns you for passing vehicles.

5

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? be able to tell where car crashes are and traffic jams so people can take other routes

What features would you want your intelligent vehicle of the future have to mitigate congestion?

Traffic maps,

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. sense what is infront of car, ell if an emergency vechile is coming.

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? It would need to be able to tell you where the congestion is

What features would you want your intelligent vehicle of the future have to mitigate congestion?

Move itself according to its surroundings

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. Softer air bags and it to know what you want to do

7

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

avoid crashes and busy areas.

What features would you want your intelligent vehicle of the future have to mitigate congestion?

a traffic map

C

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car.

Sense infront of car

8

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? It would have to self drive, comunicate, and see and hear.

What features would you want your intelligent vehicle of the future have to mitigate congestion? I would want it to detect traffic jams

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. GPS, comunjcation, self park and drive, and danger signal's

9

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

Fly

Detect traffic and where other cars or objects are.

What features would you want your intelligent vehicle of the future have to mitigate congestion?

Weather forecasts to know where & when to fly

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. communicate with other things in the same area or destination route

10

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

Know where other cars are, the destination, and the roads they travel on / systems

What features would you want your intelligent vehicle of the future have to mitigate congestion?

ways to make known where other cars are and where traffic is more sparse to reduce travel time

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car.

Safety features, car detection, airbags, talk to driver, makes sure the driver is wearing a seatbelt. makes sure the driver isn't drunken, camera's to take a picture of a bad driver's car's liscence plate

11

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? Get more detour paths.

What features would you want your intelligent vehicle of the future have to mitigate congestion?

To fly over, if it is too congested.

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. Make it fly, find detour paths. if it is in a congestion

12

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion? get make detour paths

What features would you want your intelligent vehicle of the future have to mitigate congestion?

I would want it to fly over if it's too congested

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. make it fly, find detour paths if it is in a congestion

13

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

Avoid crashes and [illegible] areas.

What features would you want your intelligent vehicle of the future have to mitigate congestion?

Able to sense the object/car around you (sight and hear)

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car. Make it tell or alarm if it [illegible] is going to be a crash in front or not.

14

Exercise 2.

If you were to design an intelligent vehicle, what would it need to do in order to avoid traffic problems or, in other words, mitigate congestion?

~~Fly~~

Detect traffic. In by using camera

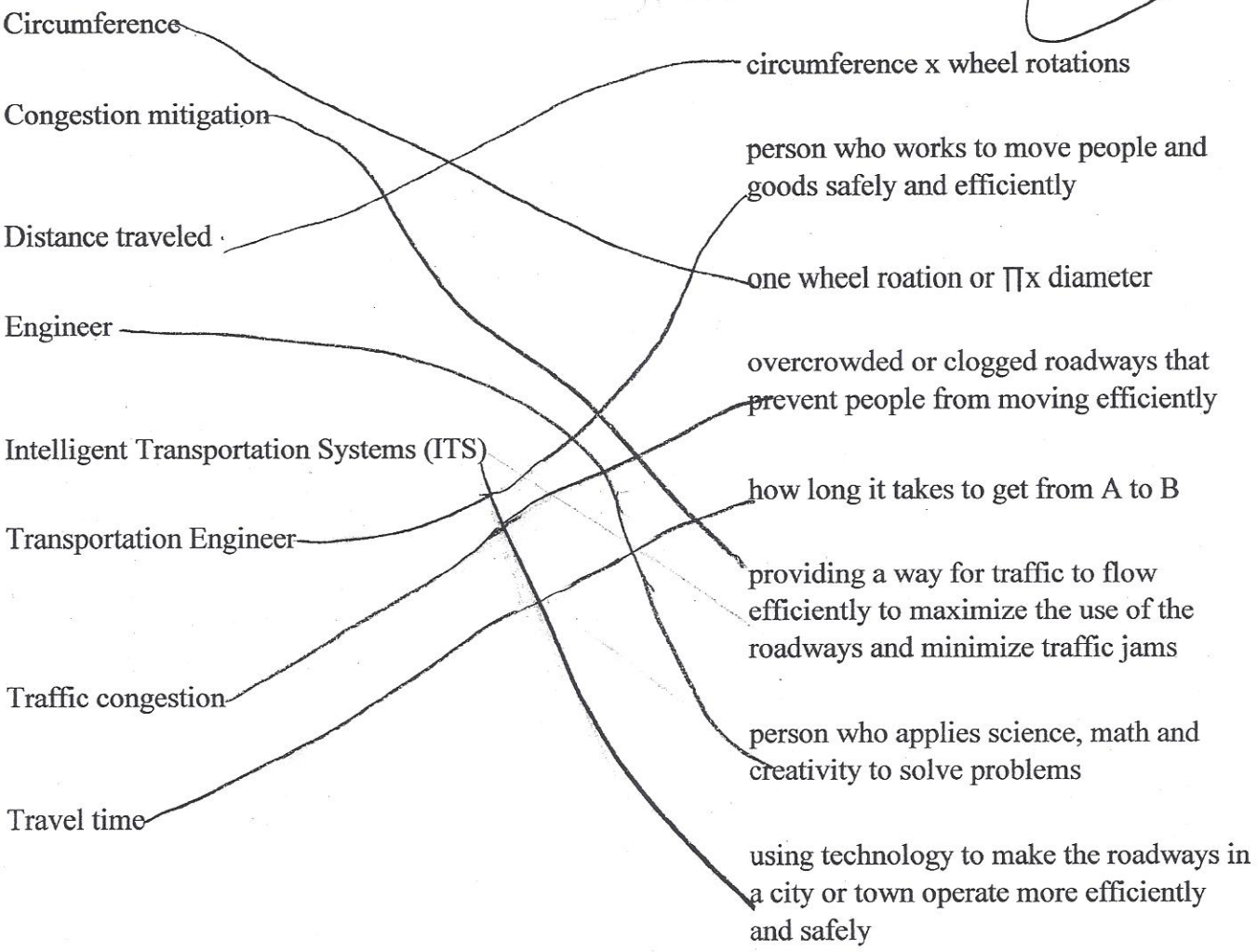
What features would you want your intelligent vehicle of the future have to mitigate congestion?

to see what exactly infront of you

Use the LEGO robotics car and any other vehicles you have seen, or ridden in, to list features that you would put in your car.

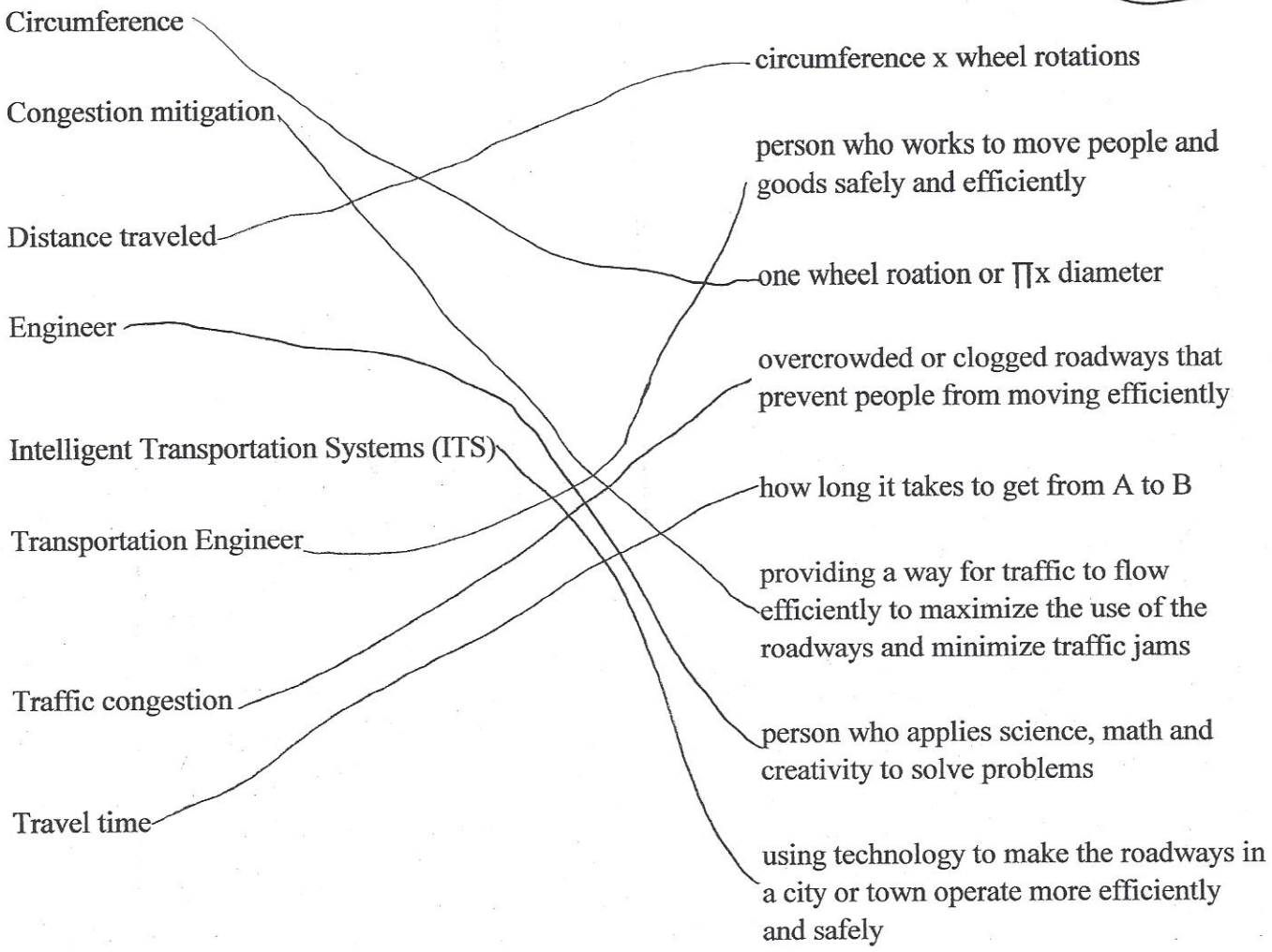
see and hear anything good infront of you

Lesson 5 Review



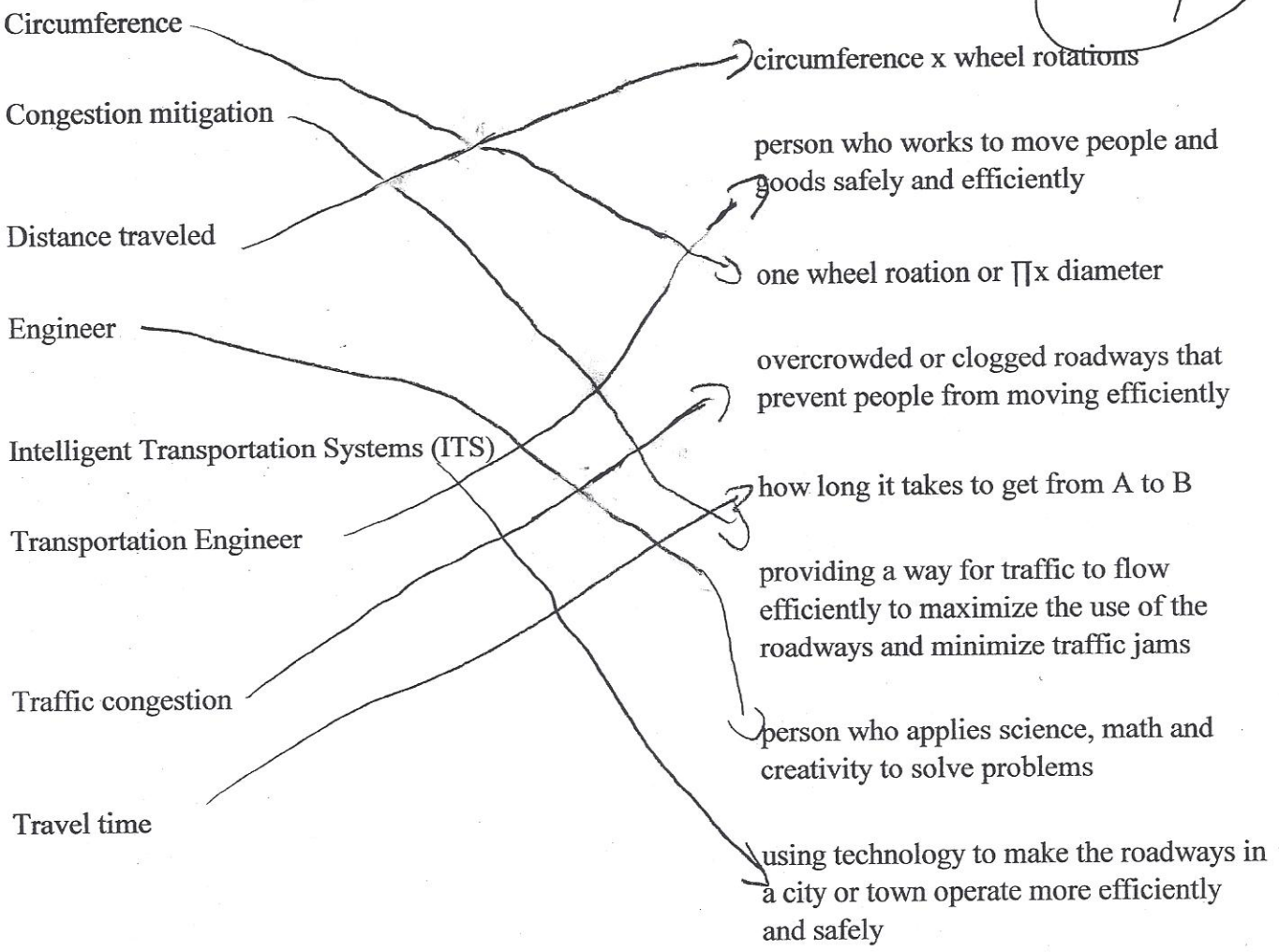
Lesson 5 Review

3



Lesson 5 Review

4

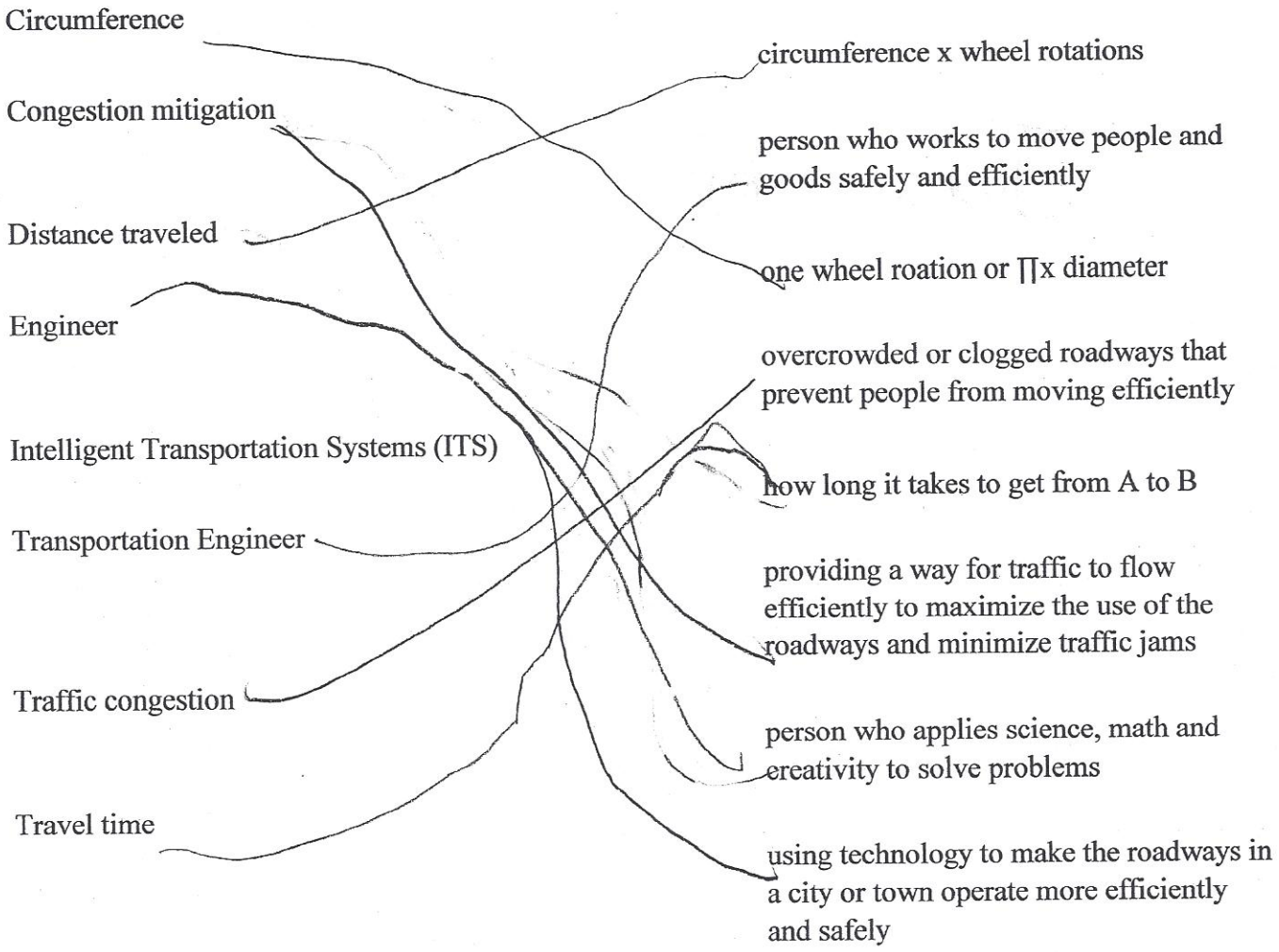


Lesson 5 Review

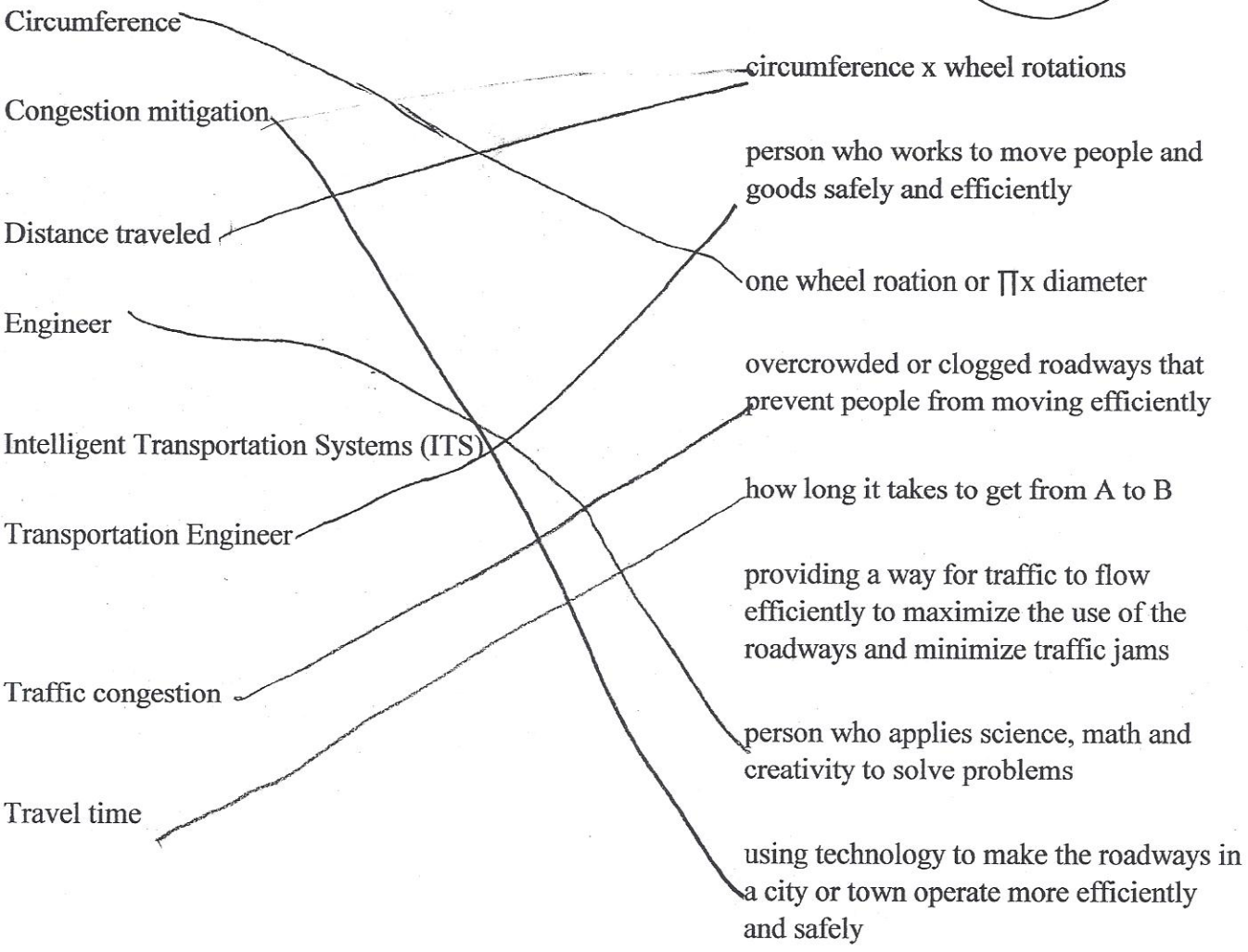
Circumference	circumference x wheel rotations
Congestion mitigation	person who works to move people and goods safely and efficiently
Distance traveled	one wheel roation or ∏x diameter
Engineer	overcrowded or clogged roadways that prevent people from moving efficiently
Intelligent Transportation Systems (ITS)	how long it takes to get from A to B
Transportation Engineer	providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Traffic congestion	person who applies science, math and creativity to solve problems
Travel time	using technology to make the roadways in a city or town operate more efficiently and safely

7

Lesson 5 Review



Lesson 5 Review



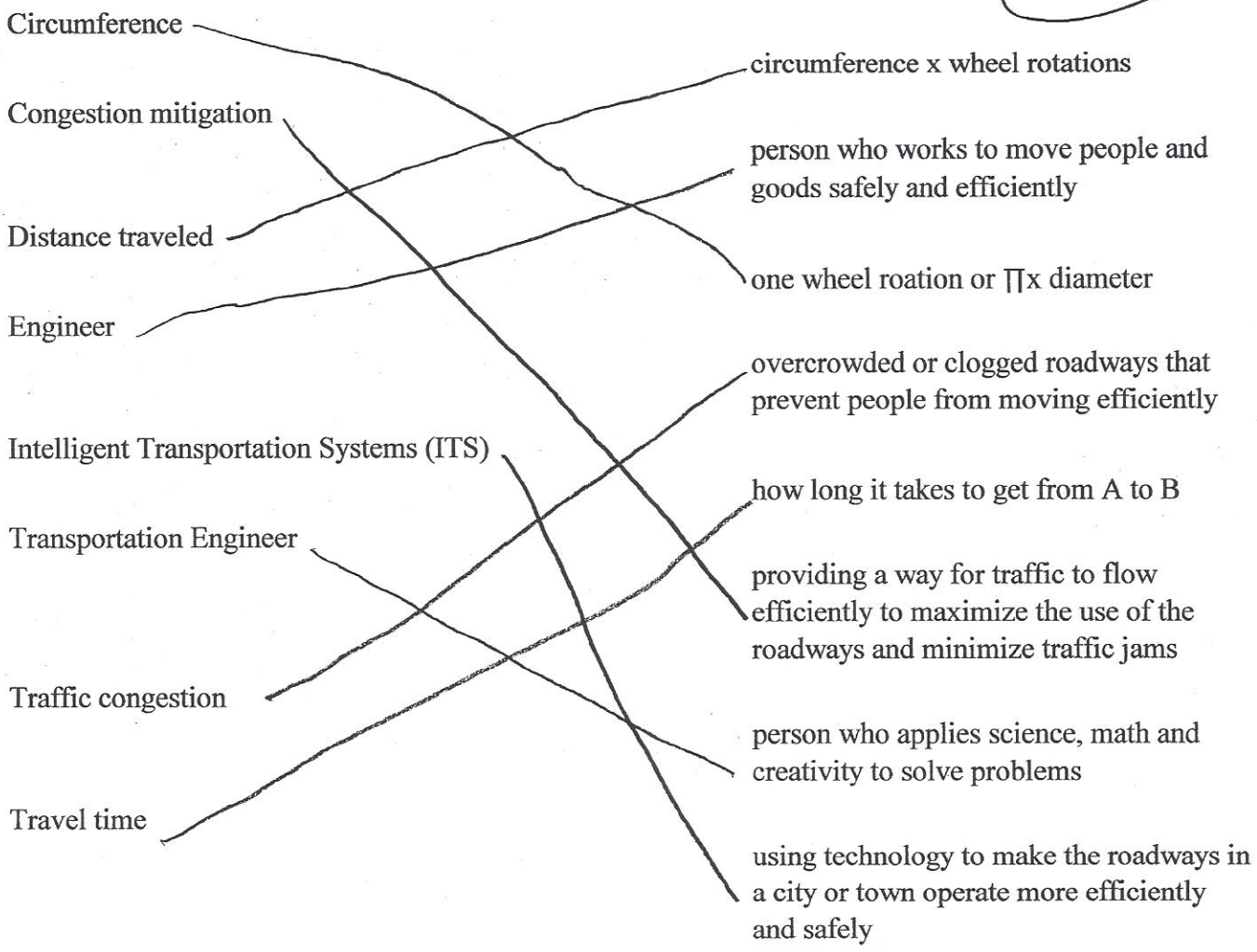
Lesson 5 Review

9

Circumference	one wheel roation or ∏x diameter
Congestion mitigation	overcrowded or clogged roadways that prevent people from moving efficiently
Distance traveled	how long it takes to get from A to B
Engineer	person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS)	using technology to make the roadways in a city or town operate more efficiently and safely
Transportation Engineer	person who works to move people and goods safely and efficiently
Traffic congestion	providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Travel time	circumference x ~~wheel~~ rotations

Lesson 5 Review

10



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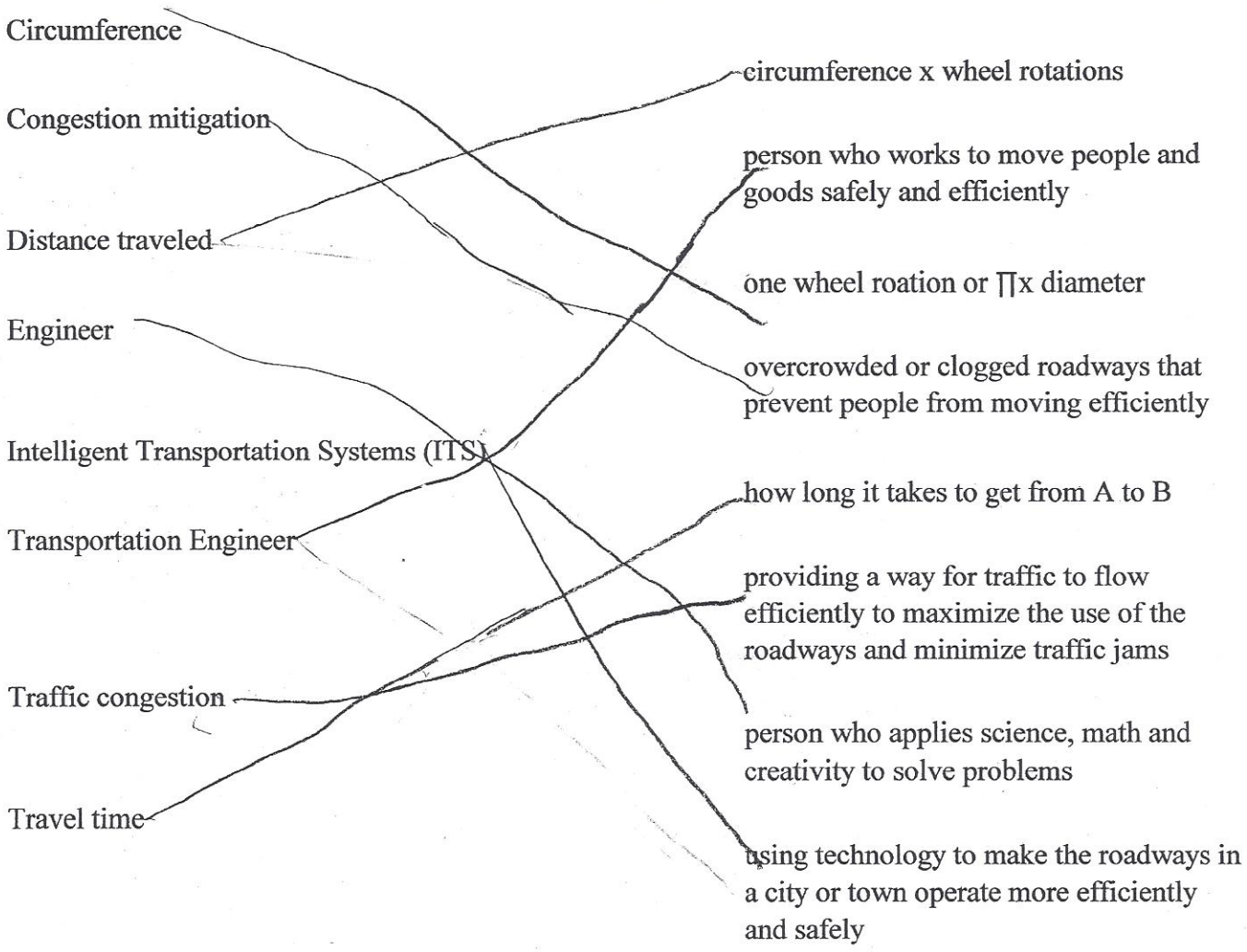
Lesson 5 Review



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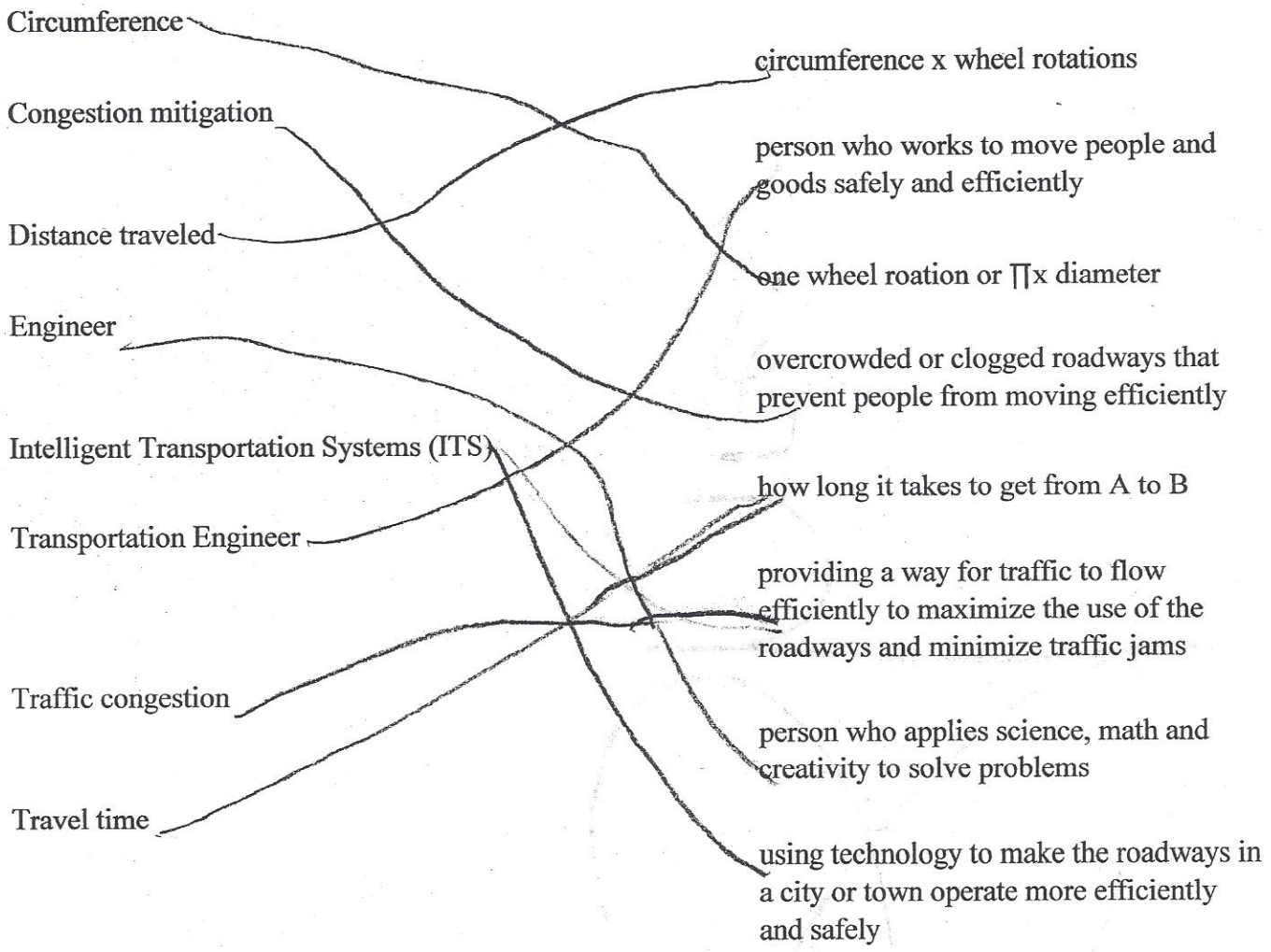
Lesson 5 Review



Lesson 5 Review

14

Circumference	one wheel roation or ∏x diameter
Congestion mitigation	providing a way for traffic to flow efficiently to maximize the use of the roadways and minimize traffic jams
Distance traveled	circumference x wheel rotations
Engineer	person who applies science, math and creativity to solve problems
Intelligent Transportation Systems (ITS)	using technology to make the roadways in a city or town operate more efficiently and safely
Transportation Engineer	person who works to move people and goods safely and efficiently
Traffic congestion	overcrowded or clogged roadways that prevent people from moving efficiently
Travel time	how long it takes to get from A to B

Appendix D

Mini Assessments-Course Material

2

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

1) weather
2) car crashes

Write down 3 examples of negative effects of traffic congestion.

1) waste of time and gas
2) air pollution
3) emergency vehicles can't get to emergencies

What does it mean to "mitigate congestion"?

I don't remember

2

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- Weather
- Car accidents

Write down 3 examples of negative effects of traffic congestion.

- Waste of gas
- angry drivers
- extra pollution

What does it mean to "mitigate congestion"?

- to prevent traffic congestion

3

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- Weather
- Crashes

Write down 3 examples of negative effects of traffic congestion.

- road rage
- high pollution
- wasted fuels

What does it mean to "mitigate congestion"?

To lessen traffic congestion

4

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- A good shopping day (Black Friday)
- A crash ahead

Write down 3 examples of negative effects of traffic congestion.

- You would waste gas
- You could get late to shool
- You could be in an emergency, and be late

What does it mean to "mitigate congestion"?

I Don't know

6

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- road damage
- crashes

Write down 3 examples of negative effects of traffic congestion.

- waste of gas
- being late
- waste of money

What does it mean to "mitigate congestion"?

7

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

Crash Nature (Fog).

Write down 3 examples of negative effects of traffic congestion.

money
environment
time

What does it mean to "mitigate congestion"?

to prevent congestion

8

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

crashes
weather

Write down 3 examples of negative effects of traffic congestion.

Some one can die because an ambulance cant get to the hospital
Some one might be late to work
some one can get home late and not get enough sleep

What does it mean to "mitigate congestion"?

I dont know

9

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

Black Friday
Road Work

Write down 3 examples of negative effects of traffic congestion.

Waste of gas
Waste of money
Waste of time

What does it mean to "mitigate congestion"?

? I DK

10

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- Weather related problems (flooding)
- Emergency things (car crash)

Write down 3 examples of negative effects of traffic congestion.

- wastes time
- wastes money
- Causes anger in car drivers

What does it mean to "mitigate congestion"?

to prevent the congestion

11

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

Write down 3 examples of negative effects of traffic congestion.

- Stressed drivers
- Lots of air population
- Waste of dollars

What does it mean to "mitigate congestion"?

I don't know

12

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- Road work
- Black Friday

Write down 3 examples of negative effects of traffic congestion.

- waste of gas
- waste of money
- nasty smelly

What does it mean to "mitigate congestion"?

?

13

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

- Black Friday
- Texting

Write down 3 examples of negative effects of traffic congestion.

- waste of gas
- waste of time
- waste of money

What does it mean to "mitigate congestion"?

?

14

Mini Assessment 1

Write down 2 examples of causes of traffic congestion.

sleeping while driving

Black friday

Write down 3 examples of negative effects of traffic congestion.

waste of gas
waste of money
Party smoke
waste of time

What does it mean to "mitigate congestion"?

idk

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion? An intelligent school bus would reduce traffic congestion by having timed stops and would follow the exact same path every day so you could time the bus to arrive at a time when roadway congestion is less likely to be a big problem.

How would an emergency vehicle detector improve roadway safety? An emergency vehicle detector would ensure that the car driver would be alert to the oncoming vehicle. This would make it safer for the driver and emergency vehicle personell

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion? An intelligent school bus can figure out where there is traffic and go another route.

How would an emergency vehicle detector improve roadway safety? cars could move out of the way before the emergency car is in view.

3

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion? It won't have the flaws of a human

How would an emergency vehicle detector improve roadway safety? Alert the driver of a threat

Mini Assessment 3

7

How can an intelligent school bus reduce roadway congestion?

Ride on less buses

How would an emergency vehicle detector improve roadway safety?

Warn you to move over

4

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion?

It would figure out the exact route to go, and not wonder away, or go another route if one was crowded.

How would an emergency vehicle detector improve roadway safety?

You would be able to move out of the way by yourself and let the veichle through, and get to the place easily.

6

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion? They can stop crashes by communicating to other cars.

How would an emergency vehicle detector improve roadway safety? It would sense other cars and road sides.

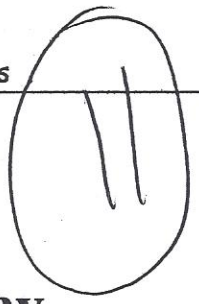
Mini Assessment 3

9

How can an intelligent school bus reduce roadway congestion? It wont have the flaws of a human

How would an emergency vehicle detector improve roadway safety? It would move out of the way

Mini Assessment 3



How can an intelligent school bus reduce roadway congestion? Buses are big, and if they can find detours, there would be less congestion on the road.

How would an emergency vehicle detector improve roadway safety? It would let the driver go with easyness

Mini Assessment 3

14

How can an intelligent school bus reduce roadway congestion?

It knows every road that is congeste

How would an emergency vehicle detector improve roadway safety?

It makes the road clearout

10

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion?

it would dropoff kids faster and more efficiantly to reduce congestion

How would an emergency vehicle detector improve roadway safety?

the emergency vehicle could get to its destination quickly and efficiantly

12

Mini Assessment 3

Shrey

How can an intelligent school bus reduce roadway congestion? It won't have the flaws of a human

How would an emergency vehicle detector improve roadway safety? It would move out of the way. It would also alert the other cars

13

Mini Assessment 3

How can an intelligent school bus reduce roadway congestion? It won't have the flaws of the human

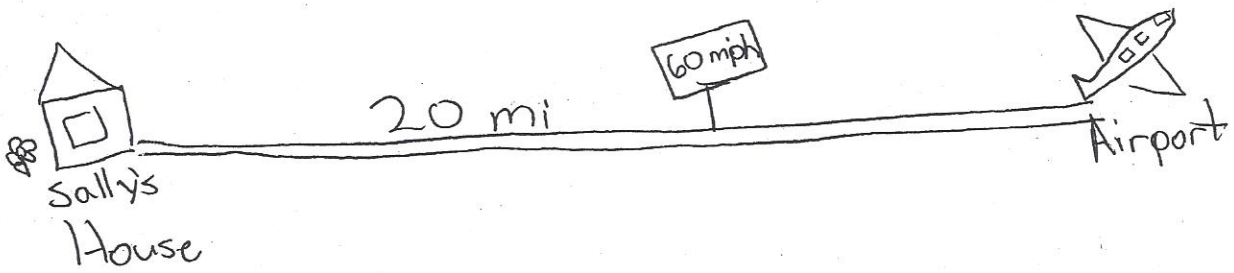
How would an emergency vehicle detector improve roadway safety? It would alert the other cars that it is coming and move out of the way

Mini Assessment 4

1

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.



travel time = $\frac{20 \text{ mi}}{60 \text{ mph}}$

travel time = [illegible] .33(60) = 19.8 min

Mini Assessment 4

2

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

distance = 20 miles
mph: 60 mph
travel time: 20 minutes

$x = \frac{20(\text{miles})}{60(\text{mph})}$

$= \frac{1}{3}(\text{hour})$

$(.33)(60)$

$= 19.8$

19.8 minutes

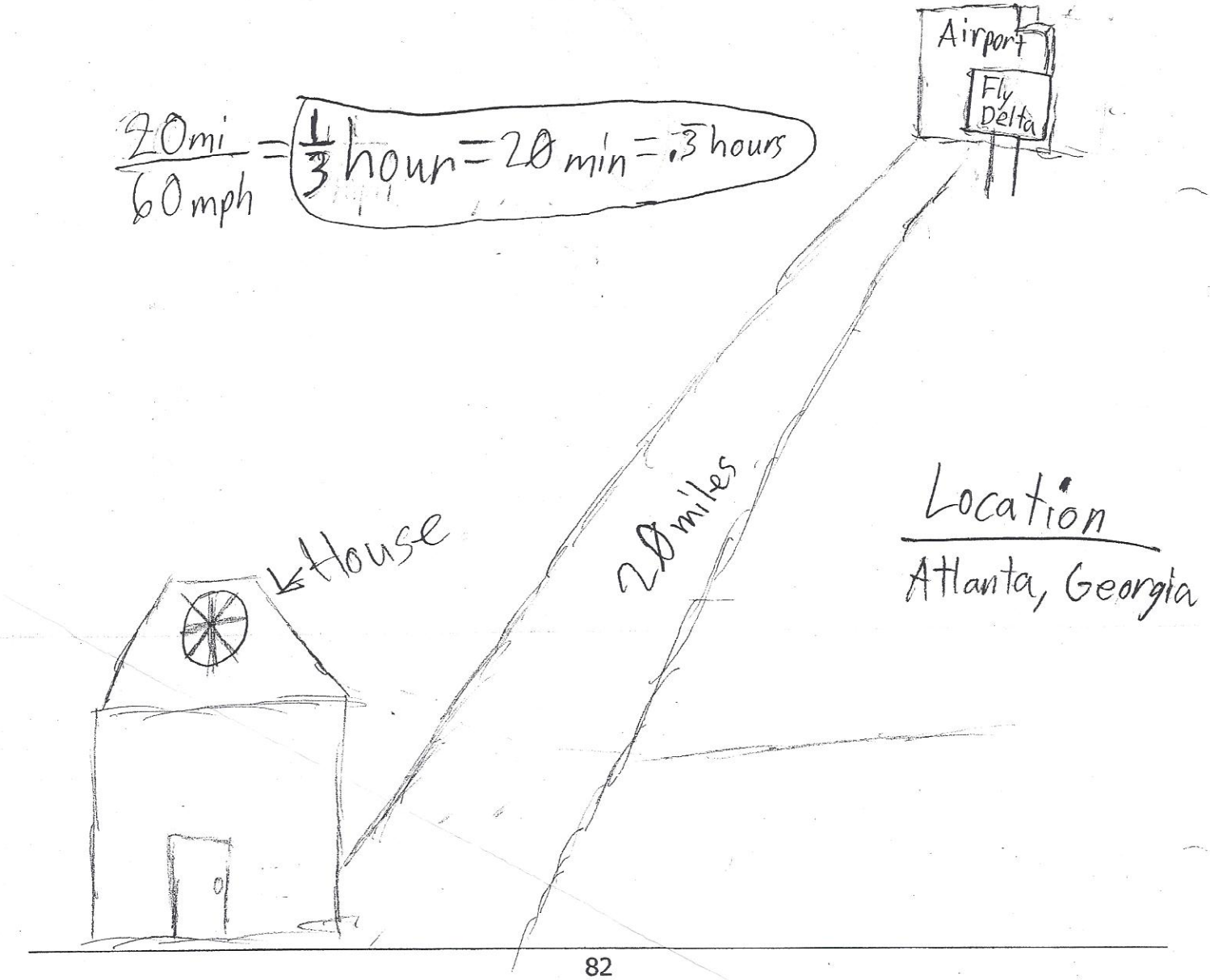
3

Mini Assessment 4

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

$\frac{20 mi}{60 mph} = \frac{1}{3} hour = 20 min = .\overline{3} hours$

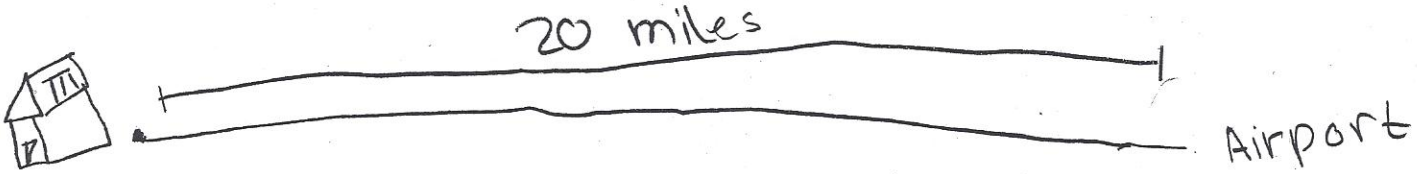


Mini Assessment 4

4

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.



time = $\frac{20 mi}{60 mph} \cdot .\overline{33}\,(60)$

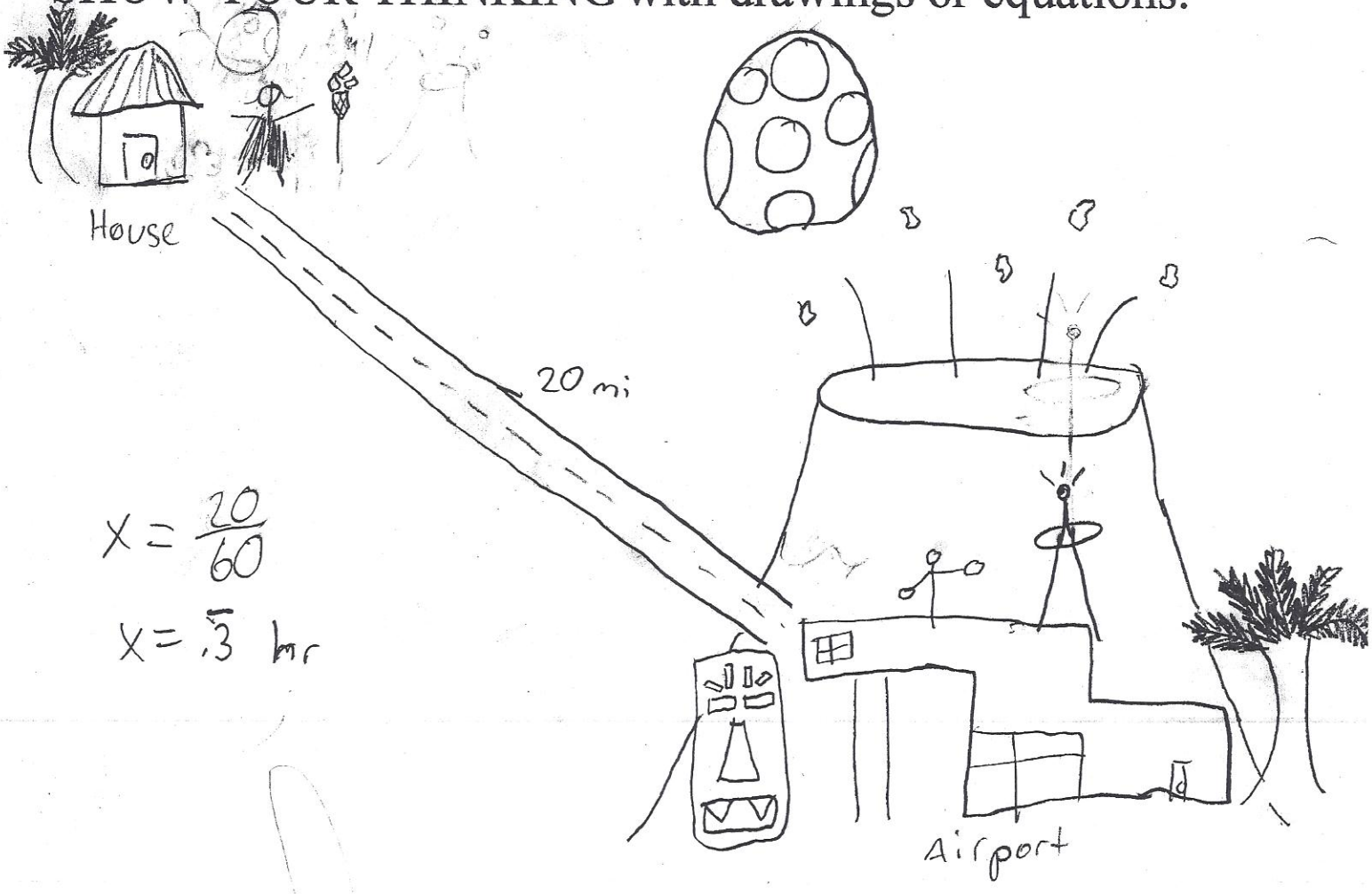
19.8 min

Mini Assessment 4

6

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.



$x = \frac{20}{60}$

$x = .\overline{3}$ hr

Mini Assessment 4

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

$\frac{20 \text{ miles}}{60 \text{ mph}} = \frac{1}{3}$

distance = 20 miles

mph = 60 mph

$\frac{1}{3} \times \frac{20}{1} = 19.8$ minutes

19.8 minutes

Mini Assessment 4

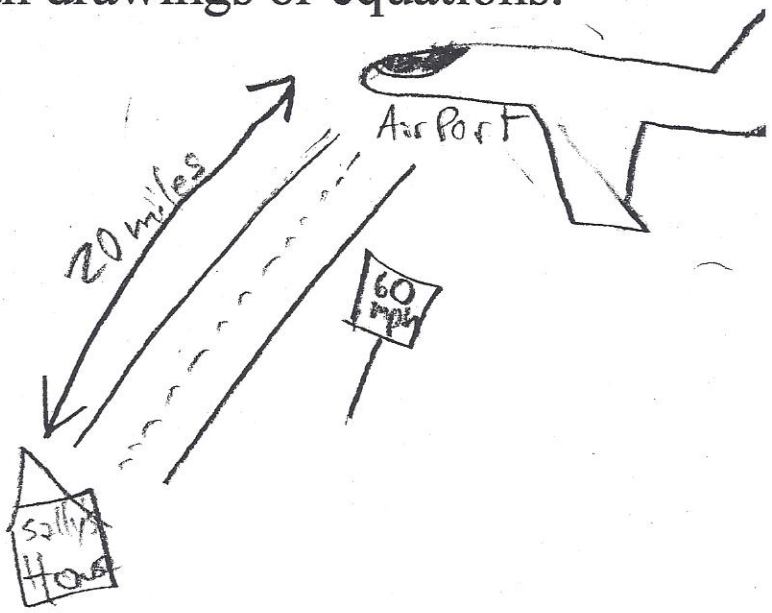
8

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

$\text{Speed} = \frac{60 \text{ miles}}{1 \text{ hr}}$

Distance = 20 miles



$\frac{60 \text{ miles}}{1 \text{ hour}} = \frac{20}{x}$

$20(1) = 60x$

$\frac{20}{60} = \frac{60x}{60}$

$x = .333 \text{ hr} \times \frac{60}{1 \text{ hr}}$

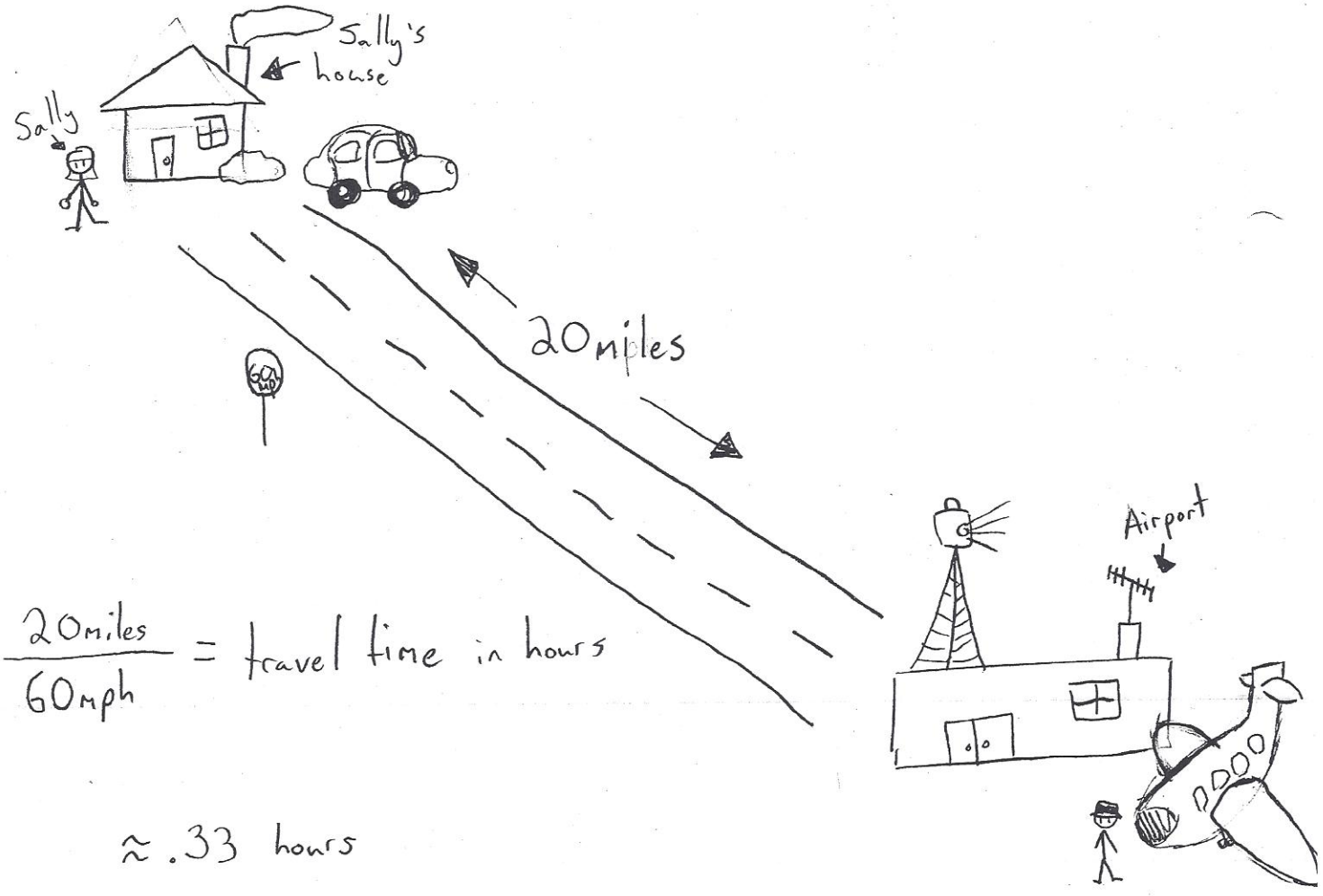
$= 20 \text{ min.}$

Mini Assessment 4

10

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.



$\frac{20 \text{miles}}{60 \text{mph}}$ = travel time in hours

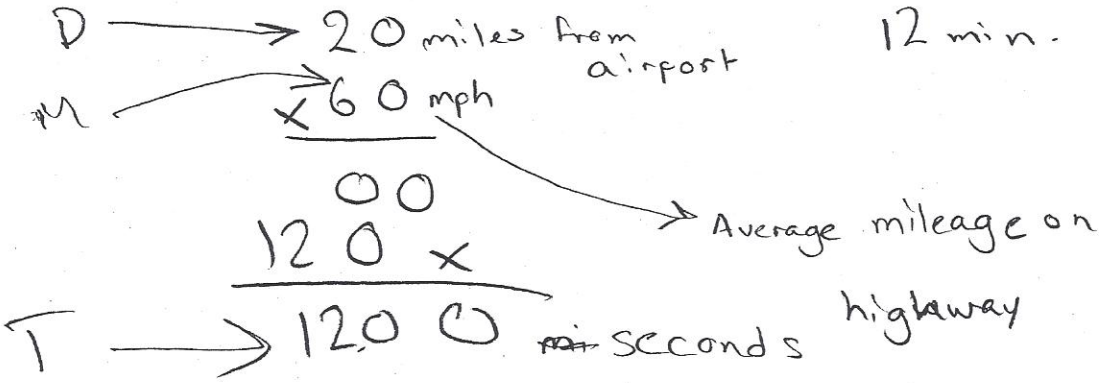
$\approx .33$ hours

Mini Assessment 4

11

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.



d = 20 miles

t = ?

s = 60 miles / hour

$s = \frac{d}{t} = 0.33$ hours

Mini Assessment 4

12

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

D = 20 = miles from airport
X60 = average mile on highway
00
120
1200 = 12 min

D = 20 miles
t =
S = 60 miles / hour

$t = \frac{d}{s} = 0.33$ hours

$t \cdot s = d \cdot t$

$\frac{t \cdot s}{s} = \frac{d}{s}$

$t = \frac{d}{s} = \frac{20 \text{ miles}}{60 \frac{\text{miles}}{\text{hour}}} = 0.33 \text{ hr}$

13

Mini Assessment 4

Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

$\frac{20\text{ (miles)}}{60\text{ (mph)}} = \frac{1}{3}$

$\frac{1}{3} \times 60^{20}$

19.8 minutes

Mini Assessment 4

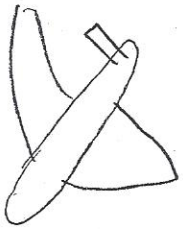
14

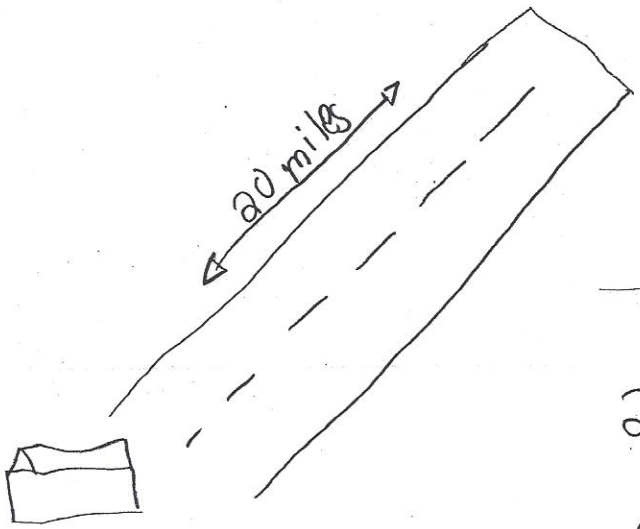
Sally is going to pick up a friend at the airport. She lives 20 miles from the airport. The average speed on the highway to the airport is 60 mph. If Sally can maintain the average speed on the way to the airport, how long should it take her to get to the airport from her house?

SHOW YOUR THINKING with drawings or equations.

speed = $\frac{60 \text{ miles}}{1 \text{ hr}}$

Distance - 20 mile





$\frac{60 \text{ miles}}{1 \text{ hr}} = \frac{20}{x}$

$20(1) = 60x$

$\frac{20}{60} = \frac{60x}{60}$

$x = .333$

$x = .333$ of 1 hr

1

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways? Ultrasonic Sensors can help drivers be more aware at night because ultrasonic can make digital images making it easy for drivers to know what is going on around them in the dark. Ultrasonic Sensors can also detect things off the road like animals and people.

3

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

Can help avoid collisions with other vehicles

4

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

It can migitate trafic conjestion by

* Detecting people on the road way
* Detect othe cars, and prevent crashes
* Detect trees, fences, bushes
*

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

It ~~cars~~ can sense other cars, roadblocks, cataracts, and accidents

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

Can help by avoid large vehicles and car masses,

8

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

If the car sensess to many peisonel in the road ahead it will take a detaur.

Mini Assessment 5

9

What other ways can an ultrasonic sensor prevent congestion on roadways?

It can prevent you from craching into anything and everything.

10

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

It keeps accidents from happening, keeps cars from running red lights (if lights send out special signals to stop the car), and thus keeps the roads clear and free of congestion!

11

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

- It can stop crashes on the road.
- It can sense emergency vehicles and go off the road.

12

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

- It can Stop crashes
- It can make people move out of the way
- It can alert people of a crash
- It can tell the person to go fast

14

Mini Assessment 5

What other ways can an ultrasonic sensor prevent congestion on roadways?

- Its stops accident which cause traffic jams.
- Stops injured people getting hitting which causes injured people