Traffic Lights

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Subject Area(s)	Number and operations, science and technology
Associated Unit	None
Associated Lesson	None
Activity Title	Traffic Lights
Header	Insert Image 1 here, right justified to wrap

Image 1

ADA Description: Students constructing a traffic light circuit on a breadboard

Caption: Students constructing a traffic light simulator circuit

Image file name: traffic_light1.jpg

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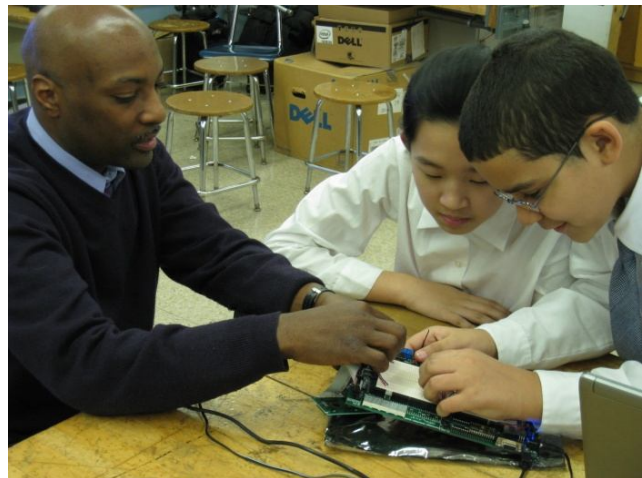
Grade Level	6
Activity Dependency	None
Time Required	50 minutes
Group Size	3
Expendable Cost per Group	US$0

Summary

Students learn about traffic lights and their importance in maintaining public safety and order. Using the Basic Stamp 2 (BS2) microcontroller, students work in teams on the engineering task of building a traffic light with specified behavior. In the process, students learn about light emitting diodes (LEDs), and how their use can save energy. As programmers, students learn two simple commands used in programming the BS2 microcontroller, and a program control concept called a *loop*.

Engineering Connection

Traffic lights (see Image 2) are the most common sight in a large city, but are often overlooked or taken for granted. However, traffic lights are very important in keeping a city running smoothly. To design an effective sequence of traffic lights, traffic engineers model and analyze traffic patterns at many street intersections over a period of time, which enables them to come up with the best order and timing of traffic signals for a particular section of a city.

Insert Image 2 here, centered

Image 2

ADA Description: A picture of three sets of traffic lights with three lights each

Caption: A traffic light

Image file name: traffic_light2.jpg

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Engineering Category

Category 3: Engineering analysis or partial design

Keywords
Traffic light, urban planning, traffic engineering, specifications, Basic Stamp 2, programming, LED, resistor

Educational Standards
- New York state intermediate-level science: Standard 1: T1.4b, T1.5a
- New York state technology: engineering design, information systems, computer technology

Pre-Requisite Knowledge   None

Learning Objectives
After this activity, students will be able to:
- Explain the importance of traffic lights and safety
- Explain and demonstrate the use of light emitting diodes and resistors
- Know about and be able to explain two BS2 commands and the programming concept called a loop

Materials List
Each group needs:
- One Parallax Board of Education #28803 with a properly installed BS2 microcontroller
- One laptop or desktop computer with the Parallax PBASIC Editor software and the USB driver (if using USB version of the Board of Education)
- Red, yellow, and green LEDs
- Three resistors 470 Ohm

To share with the entire class:
- Jumper wires as needed

Introduction/Motivation
Before automobiles were invented, horses were often used for transportation in big cities. Since there were no traffic rules for pedestrians or horse carriages, streets were often overcrowded, and movement of people and goods was therefore inefficient and sometimes even dangerous. The problem was especially serious at road intersections. One solution to this congestion problem was to use police officers to control the flow of traffic, which is still used in some parts of the world today. Another solution, which was first used in 1868, was to install a traffic light with different colors that could be used to indicate when a vehicle can "stop," "caution - be prepared to stop," or "go ahead". What colors can be used in a traffic light so that these three messages are communicated clearly to vehicles as well as pedestrians? (Answer: red or amber, yellow, and green, respectively.) The reason a traffic light needs to have a "stop and wait" - or a red light, is because it allows pedestrians or through traffic to pass a street intersection safely and efficiently on the green light, which means "go ahead". Who can come up to the board and draw a typical

intersection? (Have a student draw a diagram on the board.) How many traffic lights for vehicles are needed for this intersection? (Answer: two sets of traffic lights, one for each street.)

Design of an effective traffic light system in a modern city is a task of traffic engineers, and is an important undertaking. Traffic lights need to be placed judiciously to result in the safest and fastest movement of people and vehicles. Also important is the timing of traffic signals. For example, a traffic signal in a quiet suburb may safely be designed to cycle relatively quickly between red, yellow, and green, whereas a traffic signal at an intersection in a city business district may require longer switching times to allow traffic and pedestrians to move safely and avoid congestion.

Until recently, traffic lights contained bulky and powerful lamps, which used a lot of electrical power. In a city with many thousands of such traffic lights, this meant the use of a lot of energy and was therefore inefficient. To save energy, cities replaced lamps in traffic lights with light emitting diodes (LEDs), which use very little energy. An additional advantage of LEDs is longer service life. LEDs were first invented in 1920's, and are electrical devices that can generate bright light while using very little power. Cities that switched to LEDs were able to save a lot of energy and have less impact on the environment.

Today, we will be engineers tasked with building a traffic light for vehicles with a number of specifications provided by a local transportation agency. Specifications that we must meet are: the traffic light is to have three lights (red, yellow, green), be able to shine red, yellow, and green for a certain number of seconds each, and be able to repeat this sequence indefinitely. We will use a device called a BS2 microcontroller to control the traffic lights. For each individual light, we will use an LED. A diagram of an LED together with the LEDs we will use is shown in Image 3. An LED is represented as a triangle with a vertical bar. Notice that an LED has one wire longer than the other. The shorter wire corresponds to the left side in the diagram (the side connected to the vertical bar), and the longer wire corresponds to the right side. Finally, in the diagram, two arrows pointing away from the LED represent light.
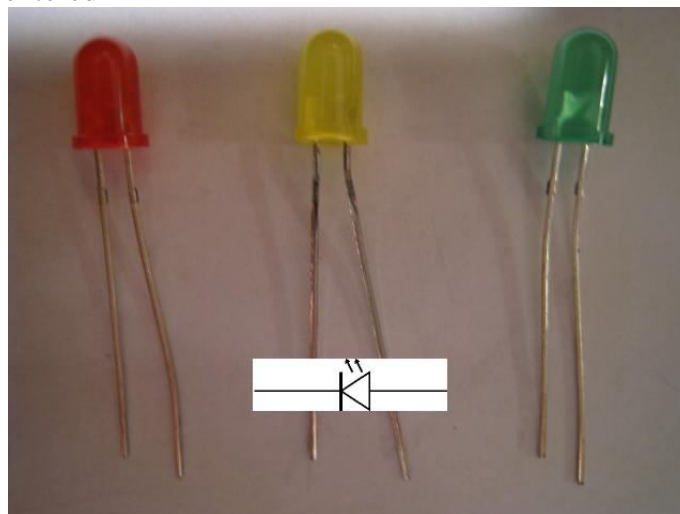
Insert Image 3 here, centered

In order to use an LED, we must connect it to a power source, which is usually a battery. The proper way to connect an LED to a power source is through a device called a resistor. A resistor limits the amount of current that can pass through it. A helpful analogy is to think of a resistor as a pipe with electricity as water. A wide pipe would correspond to a small resistor value (for example 10 Ohms) while a narrow pipe would correspond to a large-valued resistor. In this activity, we will be using a 470 Ohm resistor, shown in Image 4. Notice that in contrast to the LED, we may connect a resistor without regard to direction.
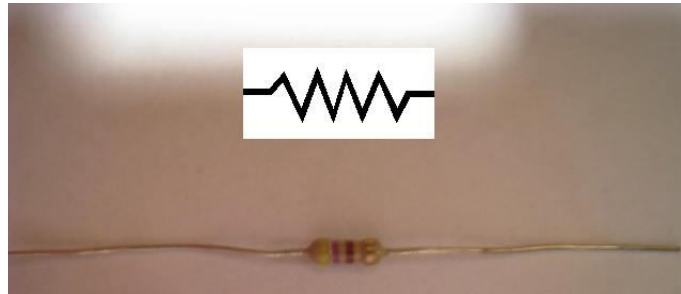
Insert Image 4 here, centered

We must use a resistor with the LED to make sure that the amount of current provided to the LED is not so great that it damages the LED. Moreover, the diode must be connected properly, with the vertical bar in the figure connected to the "ground" terminal Vss. Another way to refer to "ground" is to use the minus sign, "-". We will be using the circuit illustrated in Figure 1. To make a traffic light in which we don't have to turn the LEDs on and off manually, we will program the BS2 microcontroller to do it for us (see Image 5 with a BS2 installed on the Board of Education). A BS2 is a small computer that can perform functions programmed by engineers. This computer is a small circuit with pins for connections. Some pins are used to provide power, while others are used to program the BS2. Still other pins are used to connect the BS2 to various devices like resistors, LEDs, or even motors and other computers, although in this activity we will connect only LEDs and resistors. The pin labeled P0 in the figure denotes pin 0 on the BS2.
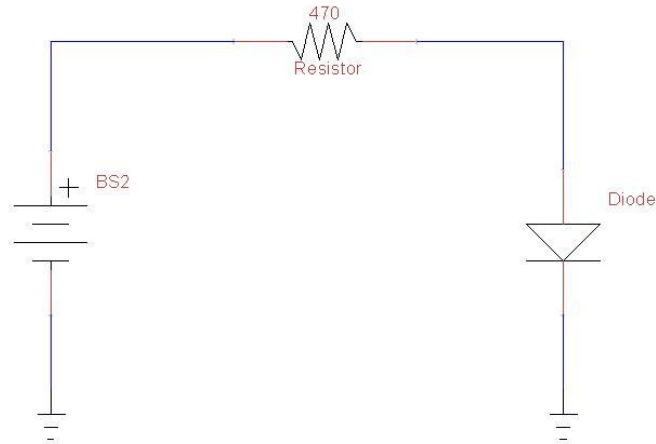
Insert Figure 1 here, centered

Figure 1

ADA Description: A diagram showing that a proper way to connect an LED to a power source is through a resistor.

Caption: A proper way to connect an LED.

Image file name: traffic_light_fig1.jpg

Source/Rights: Copyright 2009 Pavel Khazron. Used with permission.
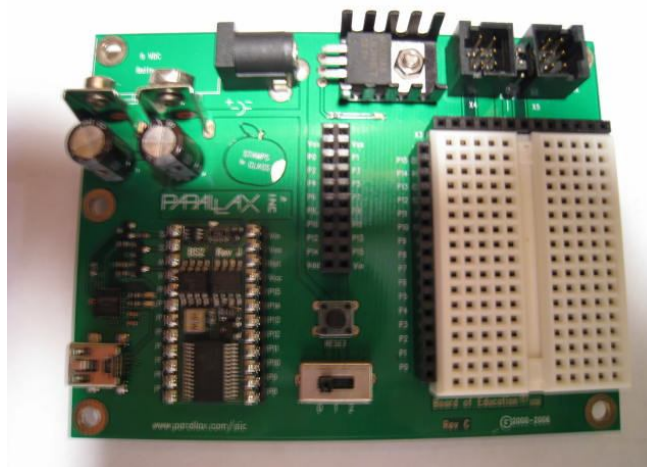
Insert Image 5 here, centered

Image 5

ADA Description: An image of a Board of Education Basic Stamp microcontroller board, with the Basic Stamp seen in the lower left side of the board.

Caption: Board of Education.

Image file name: traffic_light5.jpg

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Vocabulary/Definitions

Word	Definition
Environmental impact	The effect that human activity has on the earth, its natural processes, and all living inhabitants.
Energy	Something that can be used to perform work.
Conservation	Judicious use of energy and other resources that does not harm the environment.
System	One or more mechanisms or devices designed to do useful work, perform a function, or solve an engineering problem.
Traffic light	A system used to control the flow of vehicles and pedestrians on streets and at road intersections.
Congestion	A problematic condition that occurs when movement of traffic and pedestrians has stalled due to improper function of traffic control systems and procedures, or other reasons.
LED	Light emitting diode, an electrical device that emits light when properly connected to an electrical energy source.
Resistor	An electrical component that acts to limit the amount of electrical energy flowing through it.
Specifications	A set of standards that a device or system must meet in order to be an acceptable solution to a given engineering problem.
Microcontroller	A system that can execute user-specified commands.
Basic Stamp 2 (BS2)	An example of a microcontroller that can be connected to the outside world and used to come up with a solution to an engineering problem or set of specifications.

Procedure

Before the Activity
- Make copies of the procedure section. Acquire copies of second and third references to support class discussion.
- Set up an LED circuit using the diagram in Figure 1, as well as a working Basic Stamp traffic light as pre-activity demonstrations. Refer to introduction and the first reference as needed.
- Have a copy of the BASIC Stamp Editor installed on student computers. Also have the USB Drivers installed if using a USB version of the Board of Education.

With the Students
1. Divide the class into groups of three. Assign the following roles to each team member: builder, programmer, and tester. The builder wires the circuit, the programmer writes the program using the PBASIC editor, and the tester runs the system and performs needed adjustments or corrections. All three team members support one another by demonstrating teamwork.
2. Discuss the importance of traffic lights and street safety; support discussions with outside material listed in the references.
3. Introduce and demonstrate how to use the PBASIC editor to write, save, and run PBASIC programs. Demonstrate the Board of Education, in particular the on/off switch (for this

activity, the on/off switch should be set to position 2), and the white prototyping "breadboard" area used to build circuits. Discuss safety and precautions.

4. Pass out the Board of Education and laptops. Pass out one red LED and one 470 Ohm resistor to each group to start.

5. After demonstrating a working LED, have students build and test a basic circuit in Figure 1, using the following sequence of steps.

    a. The programmer opens the Basic Stamp editor and enters the program shown in the right-hand window in Image 6, saving the file as program1.bs2. The builder builds the circuit in Figure 1. Students read the help menu to learn about commands HIGH, LOW, and PAUSE. Note the units in which time is measured in the PAUSE command. Also have students note that the LED in this example is connected to pin P0 on the BS2. Have the tester run the program and verify the design in consultation with others.

        i. Sample questions for discussion: Looking at the BS2, how many input/output pins does the BS2 have? (Answer: 16 pins.) How many pins are used in this exercise? (Answer: 1 pin.) What are the units used in the PAUSE command? (Answer: milliseconds.) What command would one have to enter to make the Basic Stamp pause for 3 seconds? (Answer: PAUSE 3000.)

    b. The programmer opens a new file and writes the program illustrated in Image 7. All three team members look in the help menu and read about the DO LOOP statement used in this program.

        i. Sample questions for discussion: What happens when the BS2 finishes executing the commands inside a DO LOOP? (Answer: it begins executing the commands starting at the line below the DO statement.) For how many seconds does the LED flash in this example? (Answer: for 0.5 seconds.)
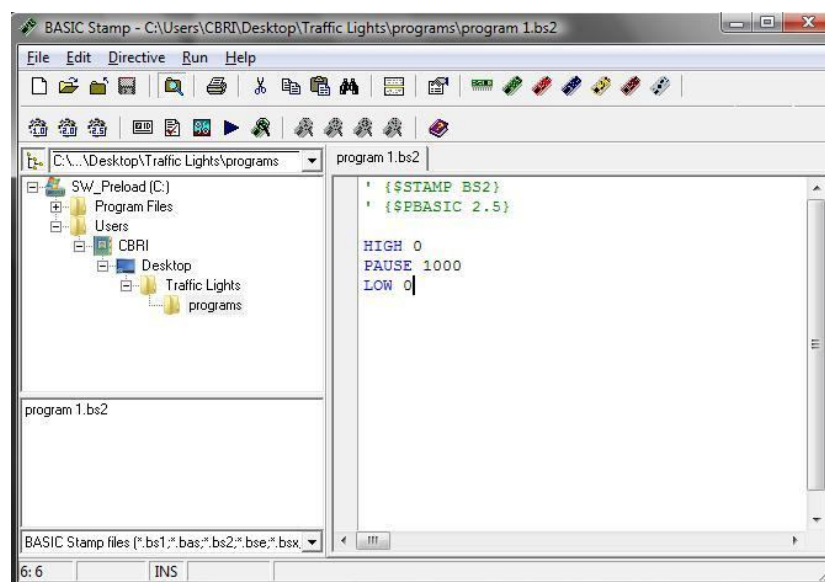
Insert Image 6 here, centered

Insert Image 7 here, centered
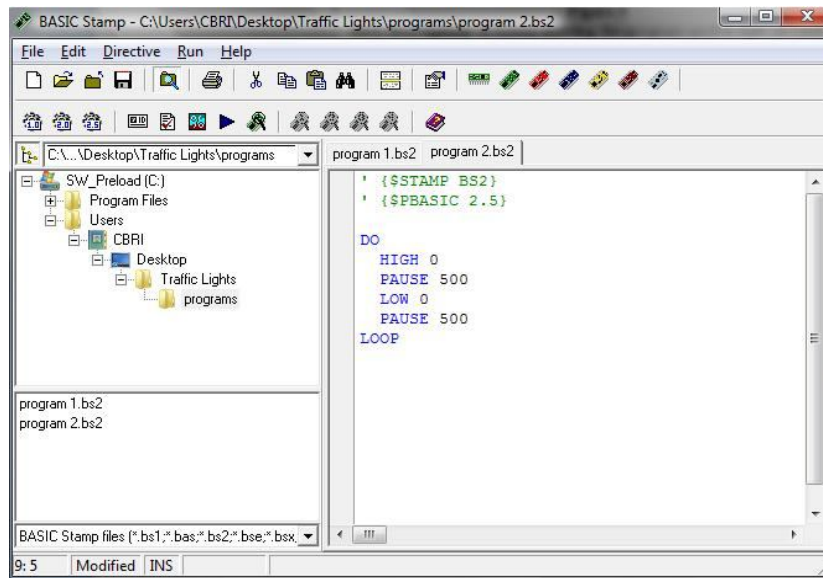
6. Pass out the yellow and green LEDs along with two 470 Ohm resistors. Now each team will build a traffic light with the following specifications. The traffic light is to have three LEDs: red, yellow, and green. The red LED should remain on for 10 seconds, the yellow for 5 seconds, and the green LED for 30 seconds. To cycle through all three LEDs is therefore to take 45 seconds. The sequence is to repeat indefinitely, simulating the operation of a real-world traffic light. To build the circuit, students will use three LED circuits as in Figure 1, and will build upon the programs they have written in step 5.

Insert Image 8 here, centered

Image 8
ADA Description: An image showing the sequence in which the LED's turn on and off to simulate a traffic light.
Caption: An LED-based traffic light controlled using a Basic Stamp.
Image file name: traffic_light8.jpg
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Attachments
Traffic_Lights_solutions.doc
program_1.bs2
program_2.bs2

Safety Issues
Ask students to refrain from touching the BS2 microcontroller and power circuitry on the board, and not to perform the activity around food or liquids.

Troubleshooting Tips
If the BS2 or the PBasic editor crashes, close and restart the editor, and cycle the power to the board.

Investigating Questions

Assessment

Pre-Activity Assessment
Sharing Experiences: Lead a class discussion about student experiences with transportation and traffic safety in general.

Activity Embedded Assessment
Analysis: In steps 5 and 6, have each group try to analyze the program before loading and running it on the BS2.

Post-Activity Assessment
Standards: Ask students to look up some traffic light standards and switching times.

Activity Extensions
An interesting extension involves building a model of a small section of a city from Lego pieces, paper mache, or recyclable material. The BS2's 16 input/output lines could be used to control

about 5 three-light traffic lights, or 8 two-light traffic lights. Have students research into ways different cities are controlling traffic, and design an appropriate model for a science fair, marking period project, or an event such as the Future City competition.

Activity Scaling
- For lower grades, have students program a BS2 already outfitted with a traffic light, and provide extra assistance when needed.
- For upper grades, have students learn about the BS2 by reading the help menu provided in the PBASIC editor.

Additional Multimedia Support
None

References
Basic analog and digital Manual, ver 1.4, Accessed September 16, 2009.
http://www.parallax.com/Portals/0/Downloads/docs/books/edu/Web-BasicAnalogDigital-v1.4.pdf

StampWorks Manual v2.1. Accessed September 16, 2009 (further discussion of LED-based projects, as well as other Basic Stamp activities).
http://www.parallax.com/Portals/0/Downloads/docs/books/sw/Web-SW-v2.1.pdf.

Traffic Safety Unit of Study. Accessed April 20, 2009 (support document containing useful traffic safety links) www.nyc.gov/html/dot/downloads/pdf/traffsafetystudy.pdf .

Let's Learn about Traffic Safety. Accessed April 20, 2009 (support material) The Department of Transportation Booklet.

Traffic Light. Accessed April 20, 2009 (detailed resource about traffic lights) http://en.wikipedia.org/wiki/Traffic_light.

Redirect URL   http://gk12.poly.edu/amps-cbri/

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