Lesson Primer: Getting Started with LEGO Mindstorms-based Science and Math Lessons

<u>To the reader:</u>

The purpose of this primer is for you, the user, to get acquainted with the LEGO Mindstorms® software and hardware so that the LEGO Mindstorms-based automated lab apparatus and robotic devices that are incorporated in each lesson are simpler to prepare and use during a lesson. We understand that there are teachers, teaching assistants, students, and others involved in K-12 classrooms who are interested in using the lessons from the AMPS/CBRI website in their respective classrooms. The lessons posted on the AMPS/CBRI website are geared towards specific K-12 grades and provide background information, lists of supplies, building instructions, as well as methods of instruction for further support. Each lesson will require the use of LEGO NXT hardware and software to take measurements and to perform complex functions. Thus, we have also included program files that work with the LEGO Mindstorms NXT software and the LEGO Digital designer. These files can be found by visiting http://gk12.poly.edu/amps-cbri/ and selecting the AEE Paper Resources under the Resources tab (or by directly pointing your browser to http://gk12.poly.edu/amps-cbri/html/asepaper/aeepaper.html).

We understand that your experience and exposure in the use of the LEGO Mindstorms hardware and software may be limited. Therefore, we have included some basic instruction so that the lessons (and the programming that accompanies them) become easier to use and implement in the classroom. We thank you for your interest and support in furthering STEM education in K-12 classrooms.

LEGO Mindstorms® Standard Kit #9797

LEGO NXT Brick

Interactive Servo Motor

**Touch Sensor**

Sound Sensor


Light Sensor

Ultrasonic sensor

<u>Accessing the building instructions:</u>

Included with each lesson are building instructions for the automated lab apparatus or robotic devices, which can be opened using an HTML-enabled web browser (Internet Explorer, Firefox, Google Chrome, etc.). Depending on how the lesson creator managed and created the instruction files, one of the aforementioned browsers should be able to open the file. To find out which one, the user can right-click on the file directly and click on "Properties" to see which browser was used to save the file.
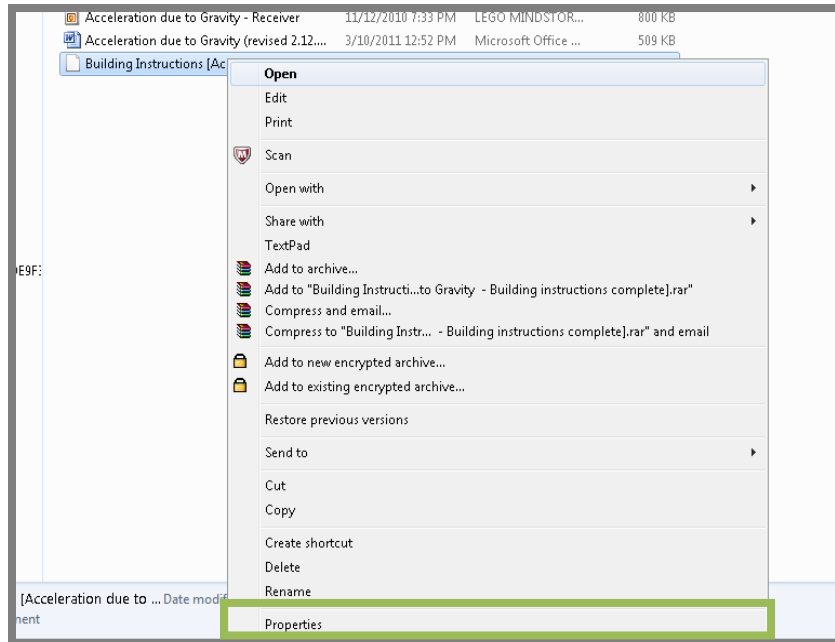

The browser that is able to open the program is shown in the "Properties" window. Click "OK" when finished.
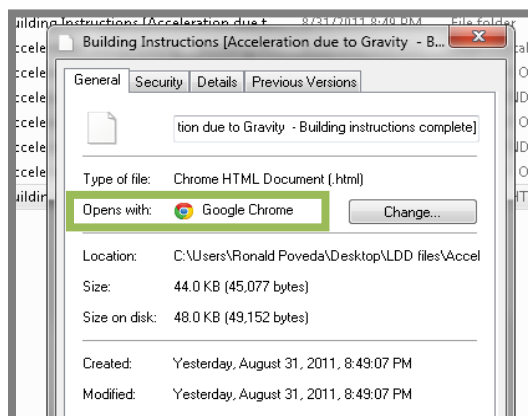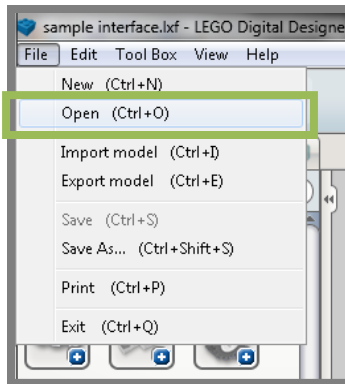
<u>Viewing and downloading building instructions using LEGO Digital Designer:</u>

LEGO Digital Designer is computer-aided design (CAD) software used for designing models built with LEGOs. This user-friendly software allows for virtual construction of the LEGO Mindstorms model of choice by putting all of the pieces together in an intuitive and visual computer program. This is usually done before building a physical model and is useful for displaying the various pieces and the step-by-step instructions used to build the model. The software is free and can be downloaded at http://ldd.lego.com.
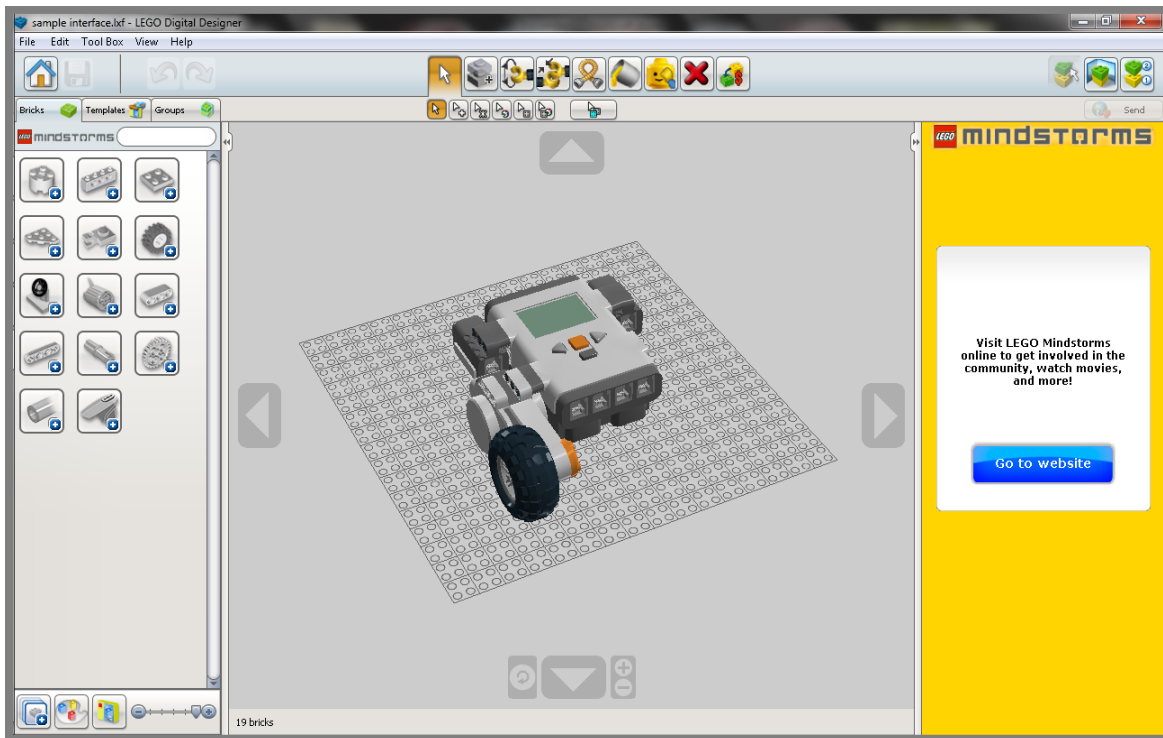
Each lesson also comes with the LEGO Digital Designer file, from which the building instructions are obtained. These files typically have the ".lxf" file extension. To open a file, the user can double-click on the file directly, or the user can go to the "File" menu and click "Open" to explore for the file on the computer. Click on the file and press "OK" to open it in Digital Designer.

The model should be shown displayed on top of a grid, with little to no additional pop-up messages. To view the step-by-step building instructions and to download them using a preferred web browser, click on the Building Guide mode icon on the top right corner of the program window. This mode can also be accessed by pressing F7 on the keyboard.

A building guide is automatically generated by the program, with logical steps on how to build the physical model step-by-step. The user can scroll through each step using the top arrows pointing left and right on the program screen, or the slider located in the same menu bar.

To produce the building instruction files using your own default web browser, click on the HTML icon on the top left of the program window. It will ask where to save the building instructions on your computer. Pick a folder to save it in, and press "OK". The building instructions can now be opened using a preferred default browser program, since it automatically saves using the default web browser.
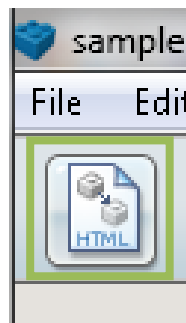
Opening and setting up the LEGO NXT programming:

Included with the lessons are LEGO NXT program files, which typically have the ".rbt" file extension. These program files are needed to run each of the automated lab apparatus and robotic devices used in each lesson. At this point, it is assumed that the user has constructed the automated lab apparatus and robotic devices to be used in the lesson. For this primer, we will be using LEGO Mindstorms Education NXT 2.0 software. When the user first opens the program, the following screen appears.
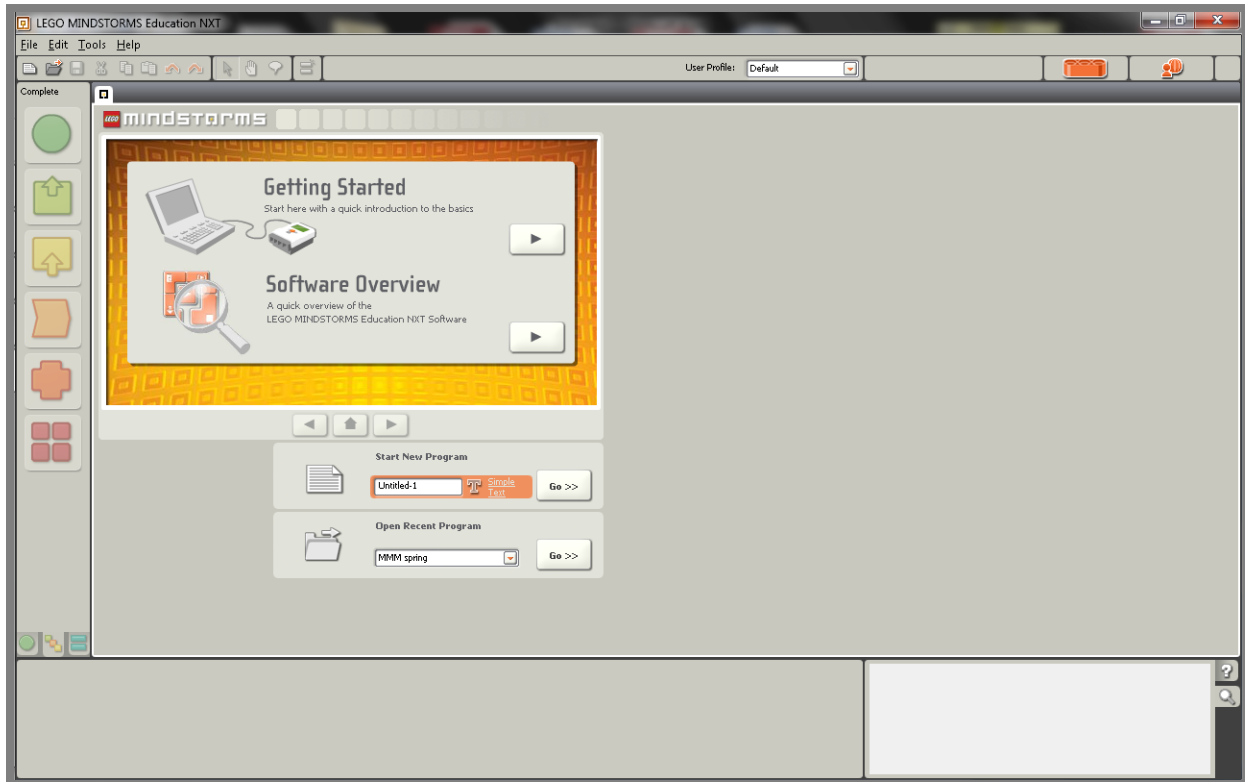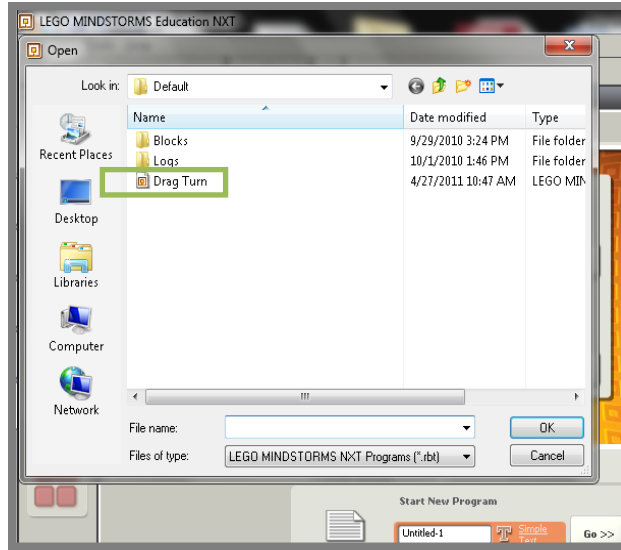

To open the program file:

1. Click on the "Open Program" icon under the main menu.
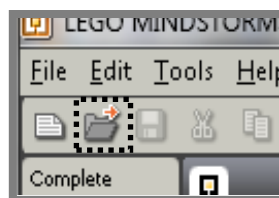
2. The "Open" window appears. Click on the program with the ".rbt" extension and click OK.

3. The programming screen should appear. It should look like a series of icons connected by virtual LEGO beams. This represents the chain of commands that were established and compiled by the programmers to enable the LEGO Mindstorms automated lab apparatus and robotic devices to perform specific functions. Each icon represents specific commands that control the motors and sensors that are integrated in each experimental setup. Depending on the type or number of functions (as well as the complexity of the programming), the type and number of icons may vary.
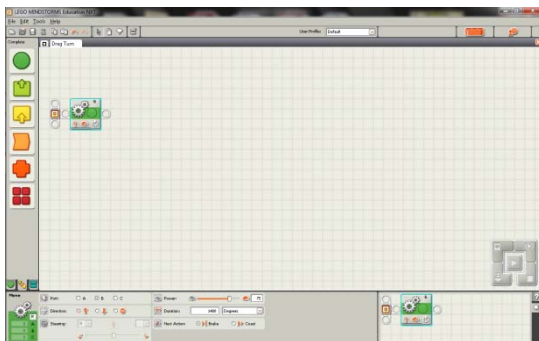

Simple program
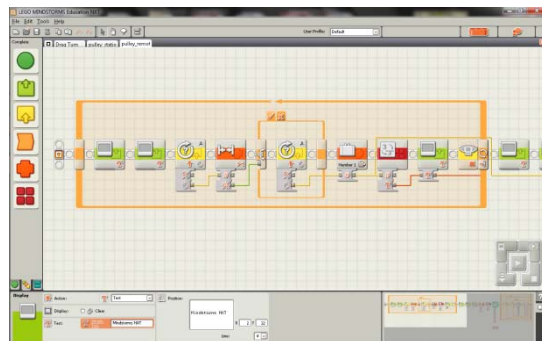
Complex program

To download a program onto the NXT brick:

1. First, ensure that the LEGO NXT brick is connected to a desktop or laptop PC containing the installed LEGO Mindstorms software. Turn on the LEGO brick by pressing on the orange button located on the front of the NXT brick, below the LCD screen.


2. Ensure that the firmware on the LEGO NXT brick is updated to reflect the latest version of the software. To do this, go to the Main Menu, click on "Tools" and click on "Update NXT Firmware."
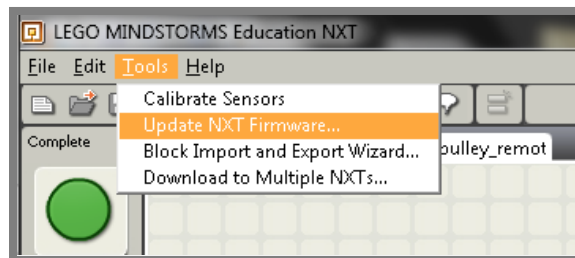
3. The "Update NXT firmware" window appears. To ensure the latest version of the NXT firmware, click on the most up-to-date version on the "Available Firmware Files" list. Press the "Download" button to start downloading the firmware onto the NXT brick. Once the download starts, DO NOT unplug the USB cord from either the PC or the LEGO NXT brick AT ANY TIME.
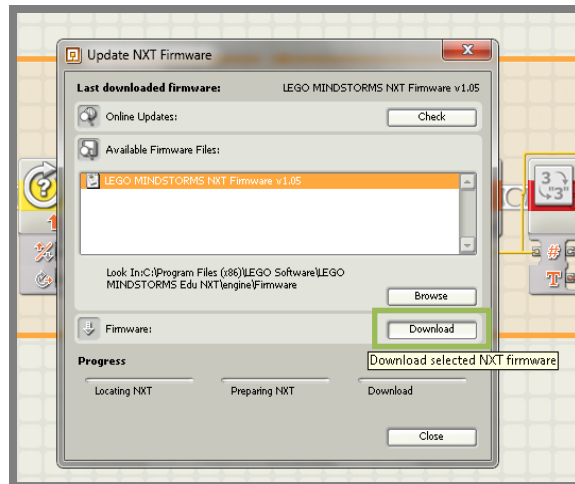
4. Once download progress is complete, close the "Update NXT Firmware" window. The firmware download only needs to be performed once before the user is able to download program files onto the LEGO NXT. The user need not download the firmware every time a new program needs to be downloaded from the user's PC to the brick.
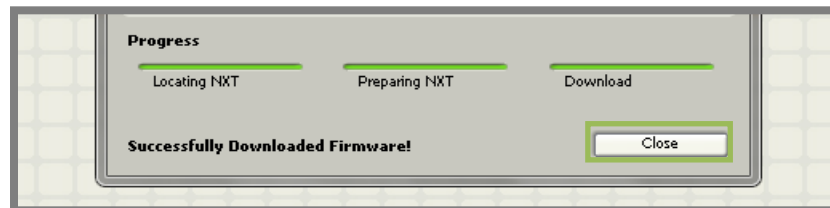

5. Now it is time to download the program file from the PC to the LEGO NXT brick. Given that the files have been created and edited by those who created the lessons, there are no modifications that need to be done on the code itself, unless otherwise specified in the lesson. Look for the 5-button controller on the lower right-hand corner of the program window. Press the button on the bottom left corner to download the program onto the LEGO NXT. It is labeled with a white arrow pointing down.

6. A new progress screen should pop up to indicate that the program is currently downloading onto the LEGO NXT. Once the download is finished, a "beep"

should be heard from the LEGO NXT, indicating that the program is now located on the brick.
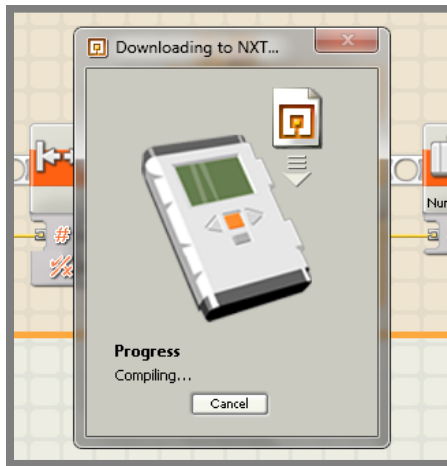
7. On the LEGO NXT brick LCD screen, the user should see a menu composed of icons. The icons can be selected using the onboard buttons below the LCD screen. The grey arrows are used to navigate through the menu options. To access the program that was downloaded, find the "My files" icon and select it by pressing the orange button.

8. Select the "Program files" icon on the next menu screen. This is where the downloaded programs are accessed on the LEGO NXT. Press the orange button to select it.

9. The icons with the names of the software file(s) downloaded onto the LEGO NXT appear on the screen. Select the file to go to the "Run" option. Now the user's individual experimental setup is ready to be operated by LEGO NXT itself! Once the automated laboratory apparatus or robotic device is ready to be run, press the orange button once again.

Final Notes:

- There may be more than 2 LEGO NXTs controlling the setup. It does not matter which NXTs contain which program, as long as both contain the appropriate programming files for proper functionality during the lesson. Follow the included lesson for additional information and instruction.

- Ensure that the batteries or battery pack connected to the LEGO NXT brick is fully charged before use.

- Unless directed by the lesson instructions, there need be no modifications to the provided programming files or icons in the LEGO NXT programs.

- LEGO Digital Designer must be accessed using a live internet connection. It will not open otherwise.