FIRST Tech Challenge

Getting Started with the *FIRST* Tech Challenge Software

July 2008
372580A-01

NATIONAL INSTRUMENTS™

Worldwide Technical Support and Product Information

ni.com

National Instruments Corporate Headquarters

11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 683 0100

Worldwide Offices

Australia 1800 300 800, Austria 43 662 457990-0, Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599, Canada 800 433 3488, China 86 21 5050 9800, Czech Republic 420 224 235 774, Denmark 45 45 76 26 00, Finland 358 (0) 9 725 72511, France 01 57 66 24 24, Germany 49 89 7413130, India 91 80 41190000, Israel 972 3 6393737, Italy 39 02 41309277, Japan 0120-527196, Korea 82 02 3451 3400, Lebanon 961 (0) 1 33 28 28, Malaysia 1800 887710, Mexico 01 800 010 0793, Netherlands 31 (0) 348 433 466, New Zealand 0800 553 322, Norway 47 (0) 66 90 76 60, Poland 48 22 3390150, Portugal 351 210 311 210, Russia 7 495 783 6851, Singapore 1800 226 5886, Slovenia 386 3 425 42 00, South Africa 27 0 11 805 8197, Spain 34 91 640 0085, Sweden 46 (0) 8 587 895 00, Switzerland 41 56 2005151, Taiwan 886 02 2377 2222, Thailand 662 278 6777, Turkey 90 212 279 3031, United Kingdom 44 (0) 1635 523545

To comment on National Instruments documentation, refer to the National Instruments Web site at ni.com/info and enter the info code feedback.

Important Information

Warranty

The media on which you receive National Instruments software are warranted not to fail to execute programming instructions, due to defects in materials and workmanship, for a period of 90 days from date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace software media that do not execute programming instructions if National Instruments receives notice of such defects during the warranty period. National Instruments does not warrant that the operation of the software shall be uninterrupted or error free.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. National Instruments will pay the shipping costs of returning to the owner parts which are covered by warranty.

National Instruments believes that the information in this document is accurate. The document has been carefully reviewed for technical accuracy. In the event that technical or typographical errors exist, National Instruments reserves the right to make changes to subsequent editions of this document without prior notice to holders of this edition. The reader should consult National Instruments if errors are suspected. In no event shall National Instruments be liable for any damages arising out of or related to this document or the information contained in it.

EXCEPT AS SPECIFIED HEREIN, NATIONAL INSTRUMENTS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S RIGHT TO RECOVER DAMAGES CAUSED BY FAULT OR NEGLIGENCE ON THE PART OF NATIONAL INSTRUMENTS SHALL BE LIMITED TO THE AMOUNT THERETOFORE PAID BY THE CUSTOMER. NATIONAL INSTRUMENTS WILL NOT BE LIABLE FOR DAMAGES RESULTING FROM LOSS OF DATA, PROFITS, USE OF PRODUCTS, OR INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF ADVISED OF THE POSSIBILITY THEREOF. This limitation of the liability of National Instruments will apply regardless of the form of action, whether in contract or tort, including negligence. Any action against National Instruments must be brought within one year after the cause of action accrues. National Instruments shall not be liable for any delay in performance due to causes beyond its reasonable control. The warranty provided herein does not cover damages, defects, malfunctions, or service failures caused by owner's failure to follow the National Instruments installation, operation, or maintenance instructions; owner's modification of the product; owner's abuse, misuse, or negligent acts; and power failure or surges, fire, flood, accident, actions of third parties, or other events outside reasonable control.

Copyright

Trademarks

Patents

For patents covering National Instruments products/technology, refer to the appropriate location: **Help»Patents** in your software, the `patents.txt` file on your media, or the *National Instruments Patent Notice* at `ni.com/patents`.

WARNING REGARDING USE OF NATIONAL INSTRUMENTS PRODUCTS

(1) NATIONAL INSTRUMENTS PRODUCTS ARE NOT DESIGNED WITH COMPONENTS AND TESTING FOR A LEVEL OF RELIABILITY SUITABLE FOR USE IN OR IN CONNECTION WITH SURGICAL IMPLANTS OR AS CRITICAL COMPONENTS IN ANY LIFE SUPPORT SYSTEMS WHOSE FAILURE TO PERFORM CAN REASONABLY BE EXPECTED TO CAUSE SIGNIFICANT INJURY TO A HUMAN.

(2) IN ANY APPLICATION, INCLUDING THE ABOVE, RELIABILITY OF OPERATION OF THE SOFTWARE PRODUCTS CAN BE IMPAIRED BY ADVERSE FACTORS, INCLUDING BUT NOT LIMITED TO FLUCTUATIONS IN ELECTRICAL POWER SUPPLY, COMPUTER HARDWARE MALFUNCTIONS, COMPUTER OPERATING SYSTEM SOFTWARE FITNESS, FITNESS OF COMPILERS AND DEVELOPMENT SOFTWARE USED TO DEVELOP AN APPLICATION, INSTALLATION ERRORS, SOFTWARE AND HARDWARE COMPATIBILITY PROBLEMS, MALFUNCTIONS OR FAILURES OF ELECTRONIC MONITORING OR CONTROL DEVICES, TRANSIENT FAILURES OF ELECTRONIC SYSTEMS (HARDWARE AND/OR SOFTWARE), UNANTICIPATED USES OR MISUSES, OR ERRORS ON THE PART OF THE USER OR APPLICATIONS DESIGNER (ADVERSE FACTORS SUCH AS THESE ARE HEREAFTER COLLECTIVELY TERMED "SYSTEM FAILURES"). ANY APPLICATION WHERE A SYSTEM FAILURE WOULD CREATE A RISK OF HARM TO PROPERTY OR PERSONS (INCLUDING THE RISK OF BODILY INJURY AND DEATH) SHOULD NOT BE RELIANT SOLELY UPON ONE FORM OF ELECTRONIC SYSTEM DUE TO THE RISK OF SYSTEM FAILURE. TO AVOID DAMAGE, INJURY, OR DEATH, THE USER OR APPLICATION DESIGNER MUST TAKE REASONABLY PRUDENT STEPS TO PROTECT AGAINST SYSTEM FAILURES, INCLUDING BUT NOT LIMITED TO BACK-UP OR SHUT DOWN MECHANISMS. BECAUSE EACH END-USER SYSTEM IS CUSTOMIZED AND DIFFERS FROM NATIONAL INSTRUMENTS' TESTING PLATFORMS AND BECAUSE A USER OR APPLICATION DESIGNER MAY USE NATIONAL INSTRUMENTS PRODUCTS IN COMBINATION WITH OTHER PRODUCTS IN A MANNER NOT EVALUATED OR CONTEMPLATED BY NATIONAL INSTRUMENTS, THE USER OR APPLICATION DESIGNER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY OF NATIONAL INSTRUMENTS PRODUCTS WHENEVER NATIONAL INSTRUMENTS PRODUCTS ARE INCORPORATED IN A SYSTEM OR APPLICATION, INCLUDING, WITHOUT LIMITATION, THE APPROPRIATE DESIGN, PROCESS AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION.

Contents

About This Manual

Conventions vii
Related Documentation viii
Programming in LabVIEW viii
Programming in LEGO MINDSTORMS viii
Third-Party Web Sites ix

Chapter 1
Overview of the *FIRST* Tech Challenge

Autonomous and TeleOperated Modes 1-1
Enabled and Disabled Status 1-2
FTC Software Components 1-2

Chapter 2
Building the Robot

Chapter 3
Connecting the Motors, Batteries, and Game Controllers

Connecting the Motors 3-1
Providing Power to the Motors 3-2
Connecting the Game Controllers 3-2

Chapter 4
Controlling the Robot with the FTC Controller Station

Downloading the Firmware 4-1
Downloading the Firmware from LabVIEW 4-1
Downloading the Firmware from LEGO MINDSTORMS 4-2
Connecting to the FTC Controller Station 4-2
Selecting the TeleOperated Program 4-3
Using the Game Controllers 4-5

Chapter 5
Modifying the Program in LabVIEW

Chapter 6
Modifying the Program in LEGO MINDSTORMS

Chapter 7
Troubleshooting the Robot

About This Manual

This manual provides tutorials you can use to get started programming a robot with the *FIRST* Tech Challenge (FTC) software. Use this manual to build and program a robot that moves according to commands you send from a game controller.

Conventions

The following conventions appear in this manual:

» The **»** symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

This icon denotes a note, which alerts you to important information.

bold Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names, front panel controls and indicators, dialog boxes, sections of dialog boxes, menu names, and palette names.

italic Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

`monospace` Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

`monospace bold` Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.

Related Documentation

The following documents contain information that you may find helpful as you read this manual.

Programming in LabVIEW

If you use LabVIEW to program the robot, refer to the following documents:

- *Getting Started with the LabVIEW Toolkit for LEGO® MINDSTORMS® NXT*—Use this manual to learn how to develop NXT VIs in the LabVIEW environment. You can use the LabVIEW Toolkit for LEGO MINDSTORMS NXT to develop FTC programs. Access this manual by navigating to the `National Instruments\LabVIEW 8.5\manuals` directory and opening `NXT_Getting_Started.pdf`.
- *LabVIEW Help*—Use the *LabVIEW Help* to access information about LabVIEW programming concepts, step-by-step instructions for using LabVIEW, and reference information about LabVIEW VIs, functions, palettes, menus, tools, properties, methods, events, dialog boxes, and so on. The *LabVIEW Help* also lists the LabVIEW documentation resources available from National Instruments. Access the *LabVIEW Help* by selecting **Help»Search the LabVIEW Help** in LabVIEW. You also can access reference information about the FTC VIs and dialog boxes directly by selecting **Help»FIRST Tech Challenge VI Reference**.
- *LabVIEW Quick Reference Card*—Use this card as a reference for information about documentation resources, keyboard shortcuts, data type terminals, and tools for editing, execution, and debugging. Access this manual by navigating to the `National Instruments\LabVIEW 8.5\manuals` directory and opening `LV_Quick_Reference.pdf`.

Programming in LEGO MINDSTORMS

If you use LEGO MINDSTORMS to program the robot, refer to the following documents:

- *LEGO® MINDSTORMS® Education NXT User Guide*—Use this manual to learn about the NXT device, the different motors and sensors available with LEGO MINDSTORMS Education NXT, and the LEGO MINDSTORMS environment. This printed manual is part of the LEGO MINDSTORMS Education NXT kit.

- *Help and Support for LEGO® MINDSTORMS® Education NXT*—Use the *Help and Support for LEGO® MINDSTORMS® Education NXT* to access information about LEGO MINDSTORMS programming concepts and reference information about LEGO MINDSTORMS blocks. Access the *Help and Support for LEGO® MINDSTORMS® Education NXT* by selecting **Help»Contents and Index** in LEGO MINDSTORMS.

Third-Party Web Sites

The following third-party Web sites contain information that you may find helpful as you use the FTC software.

- *FTC Community*—Refer to the FTC Community Web site at `www.usfirst.org/community/ftc` for official information about the FTC competition, including rules and regulations as well as support information.
- *Carnegie Mellon University Robotics Academy*—Refer to the Carnegie Mellon University Robotics Academy Web sites at `www.education.rec.ri.cmu.edu/content/events/ftc/labview` and `www.education.rec.ri.cmu.edu/content/events/ftc/nxt_g` to access FTC training materials about programming in LabVIEW and LEGO MINDSTORMS, respectively.
- *Center for Engineering Educational Outreach*—Refer to the Center for Engineering Educational Outreach (CEEO) Web site at `www.ceeo.tufts.edu` to access educational materials and sample programs that you can use to interact with an NXT device.

1

Overview of the *FIRST* Tech Challenge

The objective of the *FIRST* Tech Challenge (FTC) competition is to build and program a robot to perform certain tasks in Autonomous and TeleOperated modes.

Autonomous and TeleOperated Modes

In Autonomous mode, the robot moves without input from game controllers. You use either LabVIEW or LEGO MINDSTORMS to develop a program and then download that program to the NXT device on the robot. When you run the program, the robot moves and behaves according to instructions in the program itself.

In TeleOperated mode, the robot moves in response to commands it receives from one or two game controllers. As in Autonomous mode, you develop a program in LabVIEW or LEGO MINDSTORMS and then download that program to the NXT device on the robot. The program must contain instructions that allow the robot to receive data from the game controllers and respond accordingly. When you run the program, you then can use the joysticks and buttons on the game controllers to manipulate the behavior of the robot.

If you want the robot to respond to commands it receives from game controllers, connect the game controllers to a host computer through a USB connection. Use a controller station running on the host computer to receive data from the game controllers, convert the data to a form the program running on the NXT device can understand, and then send the data through either a USB or Bluetooth connection to the NXT device on the robot.

During the actual FTC competition, *FIRST* provides a field management system (FMS) that acts like a controller station and can connect to multiple robots at once.

Enabled and Disabled Status

At certain points in the FTC competition, the program on the NXT device must be running, but the robot cannot move. For example, at the beginning of the Autonomous part of the competition, you must run the Autonomous program on the NXT device, place the robot on the field, and return to the team area. The robot cannot start moving until all teams have placed their robots on the field and returned to their positions. Similarly, between the Autonomous and TeleOperated parts of the competition, the robots must be running in TeleOperated mode but cannot move until the judges have finished tallying the scores for the Autonomous portion.

During these times, the FMS sets the status of the robots to **Disabled**. The program you run on the NXT device must handle the Disabled status such that the robot does not move and does not respond to any commands from the game controllers. When the FMS sets the status of the robots to **Enabled**, the program you run on the NXT device must recognize this change in status. The program must handle the Enabled status such that the robot then starts moving or responding to commands from the game controllers.

FTC Software Components

The FTC software includes LabVIEW, LEGO MINDSTORMS Education NXT, and the LabVIEW Toolkit for LEGO MINDSTORMS NXT, as well as FTC-specific LabVIEW VIs and LEGO MINDSTORMS blocks. You can use this software to program a robot in either LabVIEW or LEGO MINDSTORMS. The FTC software also includes a controller station, accessible by navigating to the `National Instruments\LabVIEW 8.5\examples\FTC Toolkit\FTC Controller Station` directory or the `LEGO Software\LEGO MINDSTORMS Edu NXT\examples\FTC Toolkit\FTC Controller Station` directory and opening `FTC Controller Station.exe`.

In the following chapters, you can build a robot, program the robot with the FTC software, manipulate the behavior of the robot with a game controller, modify the program, and manipulate the behavior of the robot again.

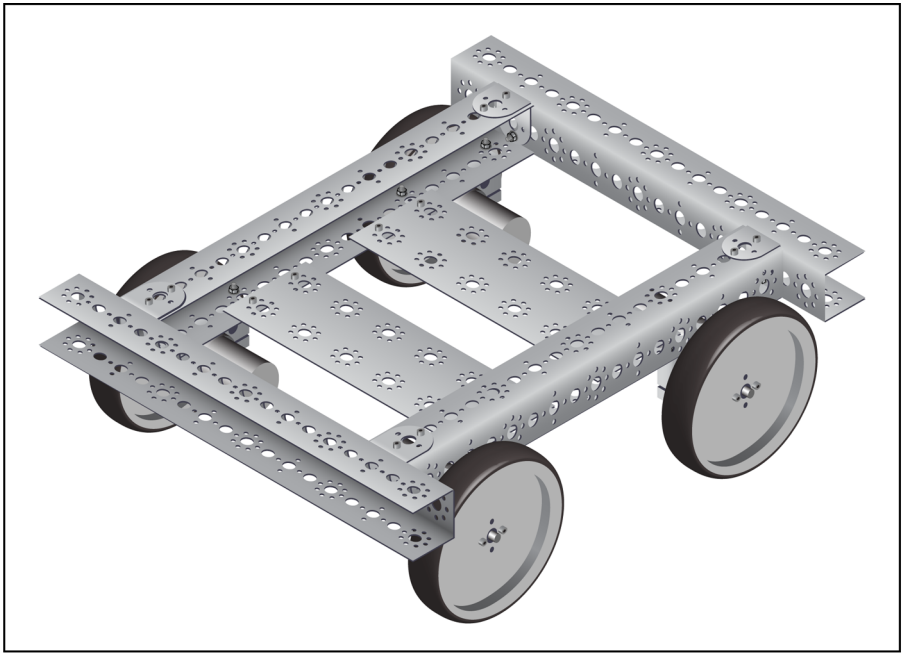
2

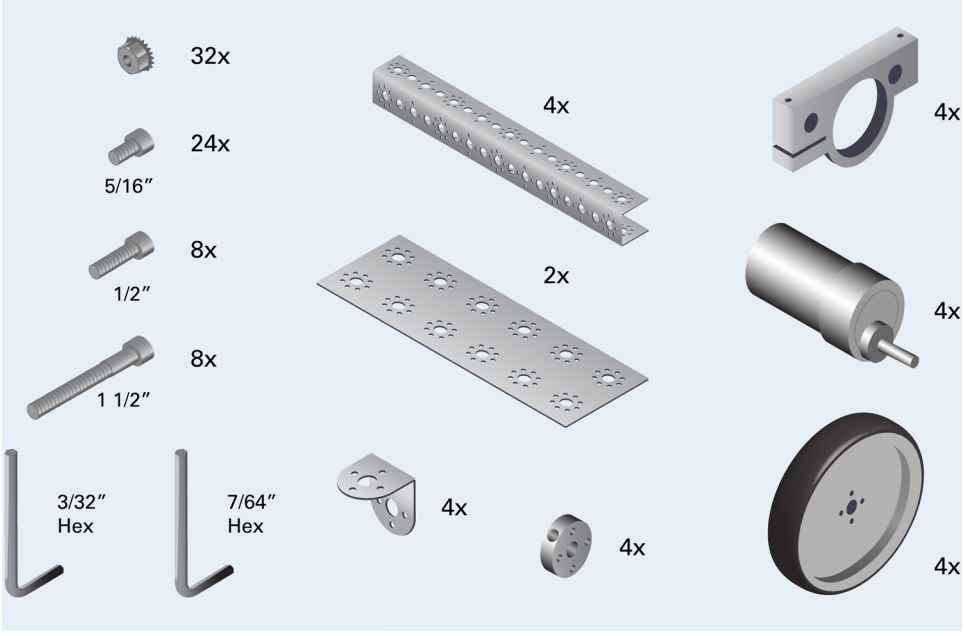
Building the Robot

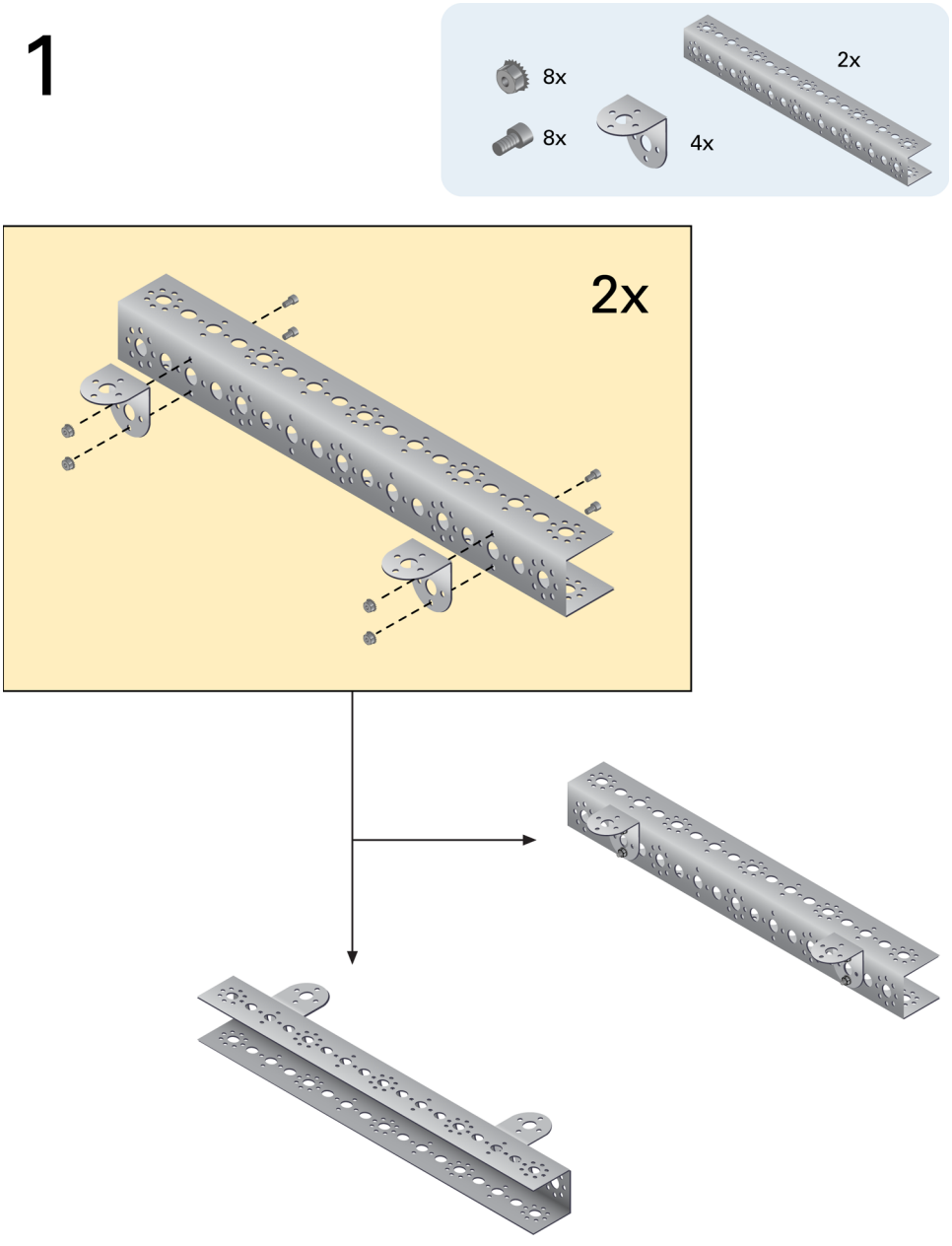
Follow the illustrations in this chapter to build a robot using hardware available in the *FIRST* Tech Challenge (FTC) kit.

Note The robot you build in this chapter works with the programs discussed in later chapters of this manual. However, the robot and the programs in this manual are only examples of the kinds of robots and programs you can develop for the FTC competition. You can build a robot of any shape or size and design programs to manipulate the behavior of the robot in whichever way you want to accomplish the goals of the FTC competition.

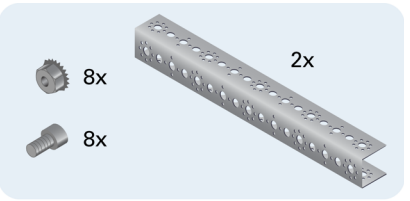
The first illustration in this chapter shows the completed hardware assembly of the robot as well as a list of parts. Ensure you have all the necessary parts before beginning to build the robot.

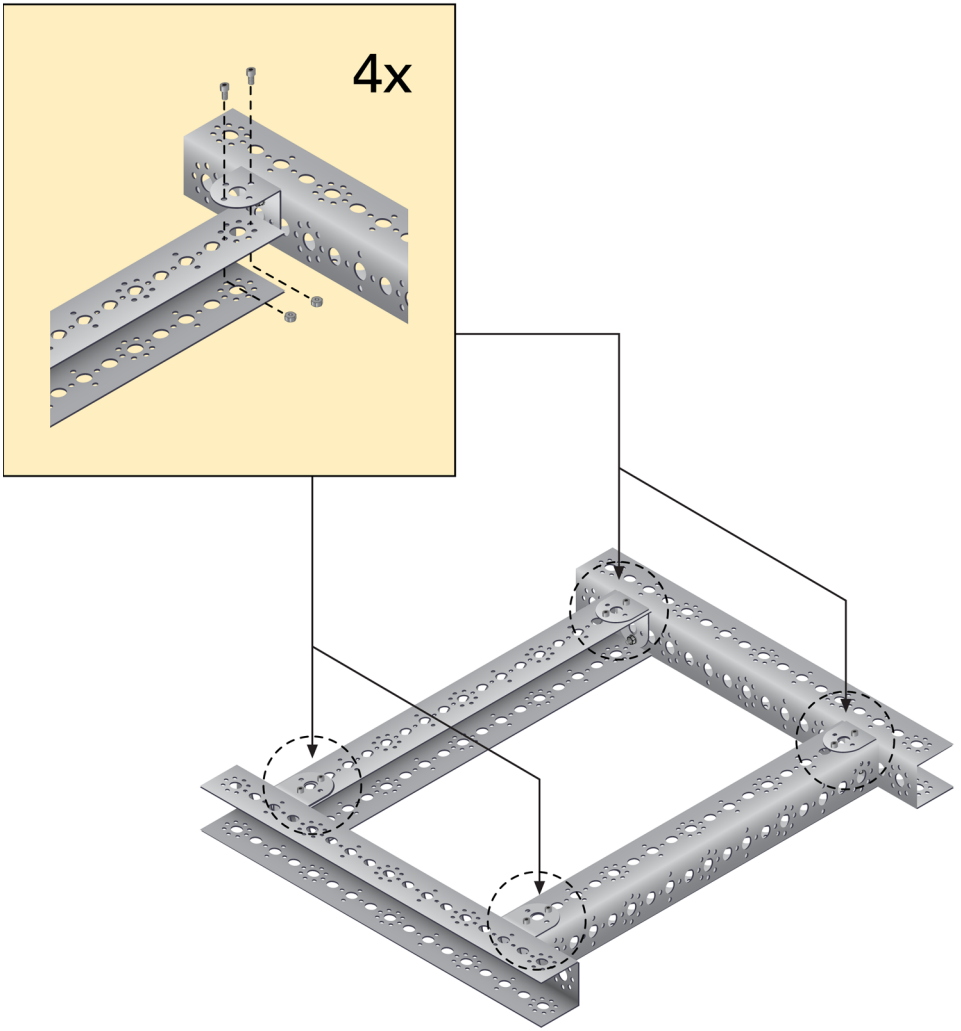



32x
24x
5/16″
8x
1/2″
8x
1 1/2″
3/32″
Hex
7/64″
Hex
4x
4x
2x
4x
4x
4x
4x

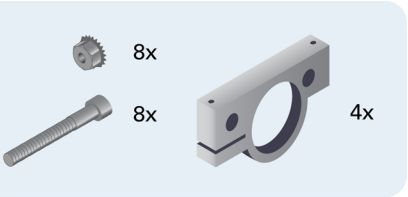

1
8x
8x
4x
2x
2x

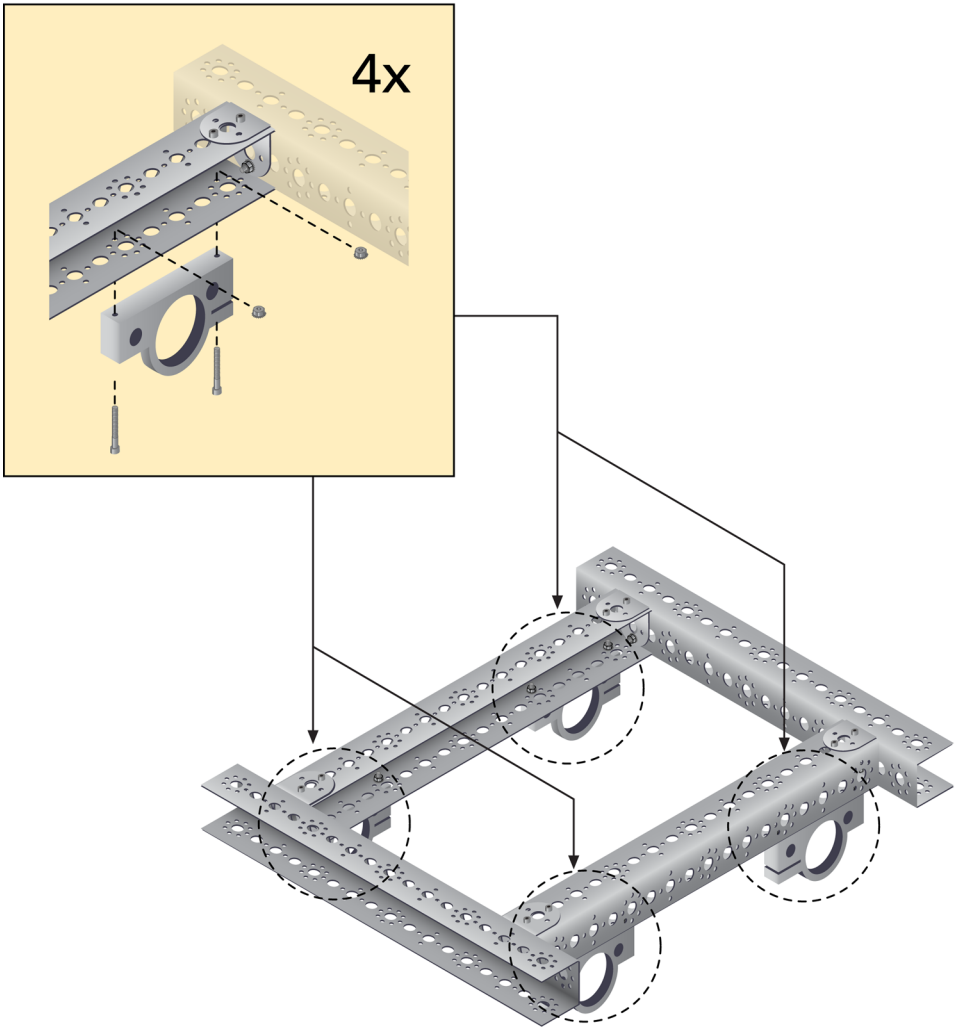
2



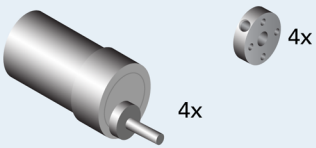


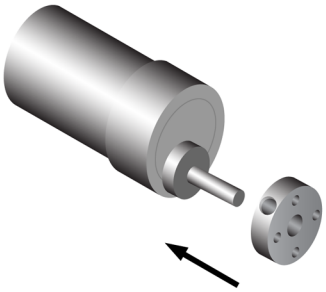
3



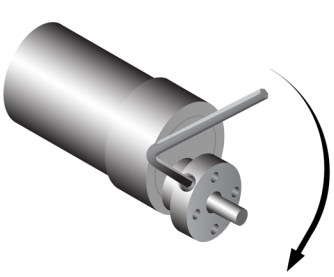


4

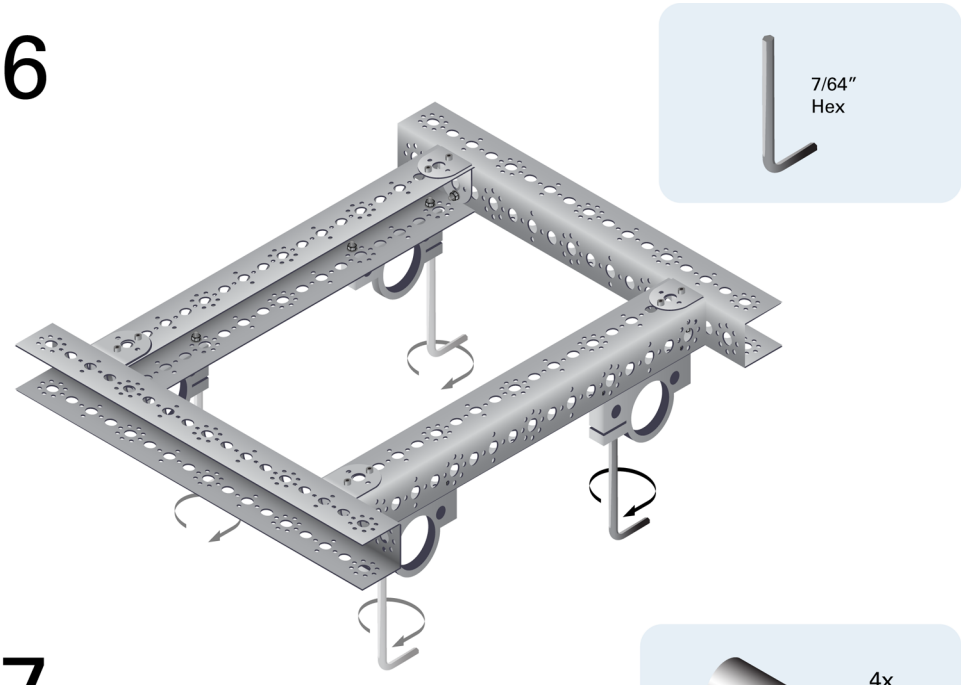




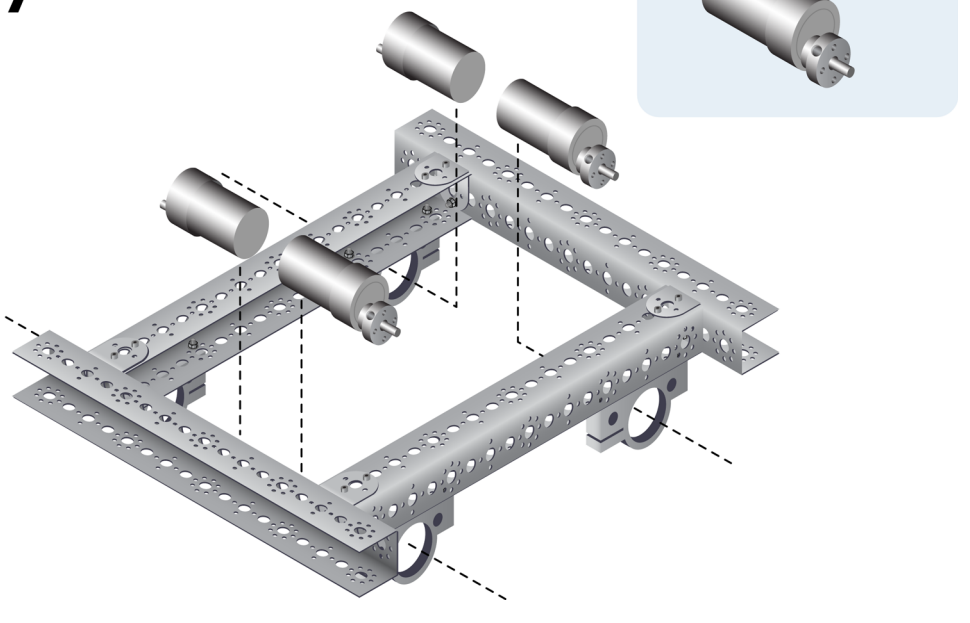
5

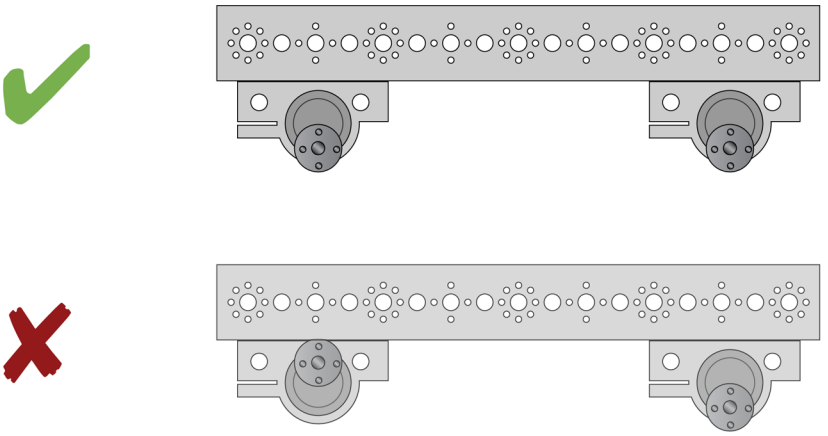


6

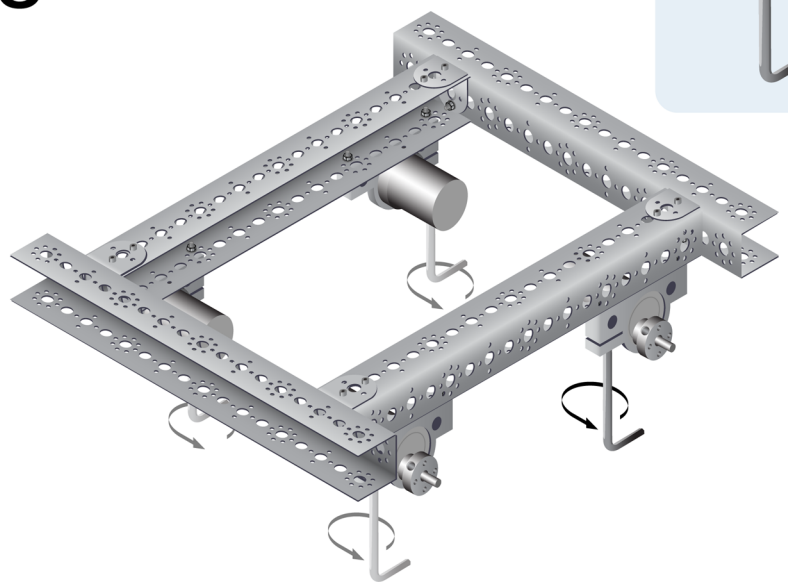


7

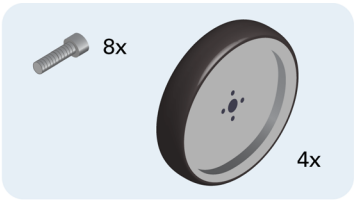


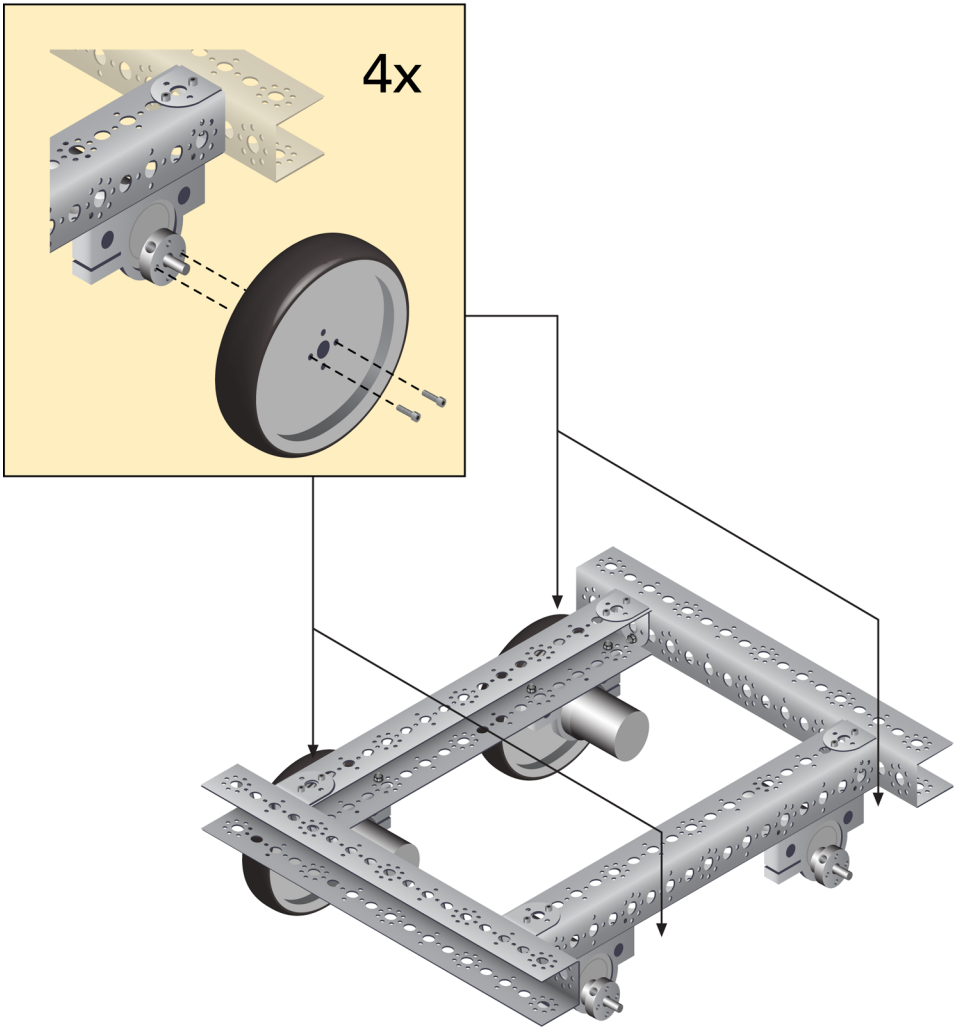


8

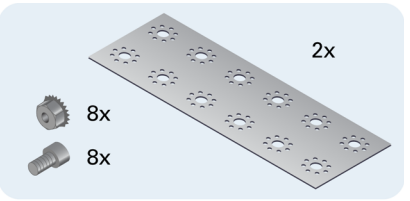


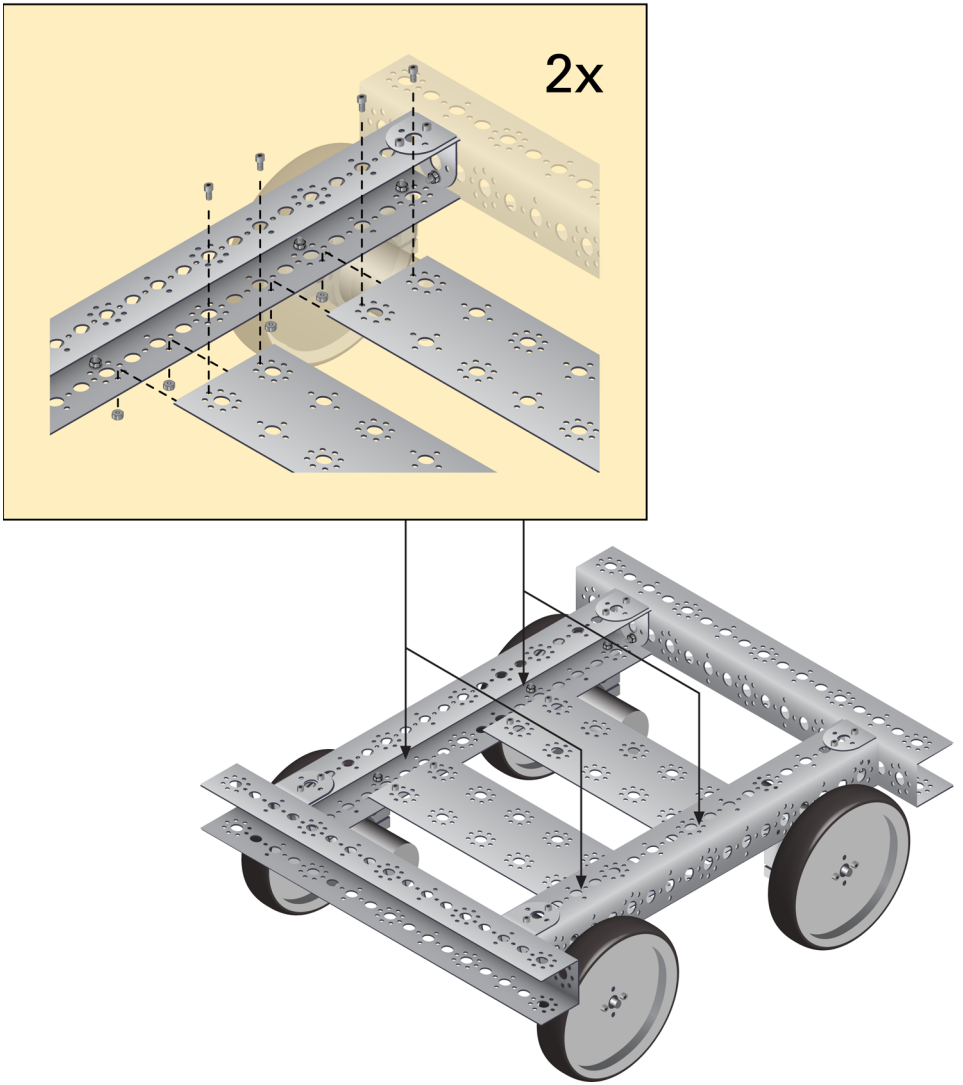
9



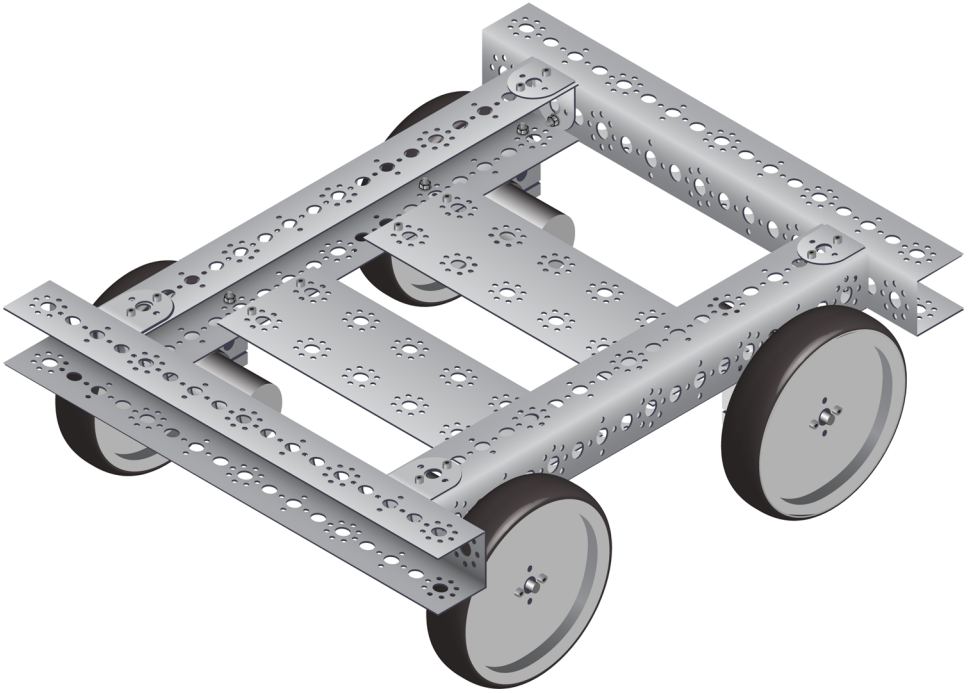


10





11



3

Connecting the Motors, Batteries, and Game Controllers

The robot you build in Chapter 2, *Building the Robot*, is not complete because it cannot perform any automated tasks. You must connect the motors to the NXT device so that the program running on the NXT device can move the motors. You also must provide power to the motors. Finally, you must connect the game controllers to the host computer on which you want to run the *FIRST* Tech Challenge (FTC) Controller Station.

Connecting the Motors

You need the following hardware parts to connect the motors to the NXT device:

- one black 6-wire cable
- one motor controller
- two split gearhead motor connection wires

Complete the following steps to connect the motors to the NXT device.

1. Connect one end of the black 6-wire cable to any of ports 1–4 on the NXT device.
2. Connect the other end of the black 6-wire cable to a sensor terminal on the motor controller. Because this motor controller is connected directly to the NXT device, this motor controller is motor controller 1 on the port.
3. Connect the base end of a gearhead motor connection wire to the motor controller.
4. Connect one of the split ends of the gearhead motor connection wire to the gear head of the motor you want to use as the front left motor.
5. Connect the other split end of the gearhead motor connection wire to the gear head of the motor you want to use as the rear left motor.
6. Repeat steps 3 through 5 for the front and rear right motors of the robot. All four motors now are connected to the NXT device through motor controller 1.

Note Instead of wiring the corresponding front and rear motors together, you also can wire the two front motors together and the two rear motors together. If you use this second method, however, be sure to program the left motors to move in the reverse direction of the right motors.

Providing Power to the Motors

You need the following hardware parts to provide power to the motors:

- one battery pack
- one "Y" quick connect cable

Complete the following steps to provide power to the motors.

1. Connect one end of a "Y" quick connect cable to a battery pack.
2. Connect the other end of the "Y" quick connect cable to a power terminal on motor controller 1. Because all four motors are connected to motor controller 1, all four motors now can receive power.

Connecting the Game Controllers

When the robot is in TeleOperated mode, the robot responds to commands it receives from one or two game controllers. Connect each game controller to a host computer using the attached USB plug.

You now can configure the FTC Controller Station to send data from the game controllers to the program running on the NXT device. In the previous sections of this chapter, you connected the motors to the NXT device and provided power to the motors. Therefore, after you configure the FTC Controller Station and program the robot appropriately, the robot can move according to commands you send from the game controllers.

4

Controlling the Robot with the FTC Controller Station

After you build the robot and connect the hardware to the NXT device, you can use the *FIRST* Tech Challenge (FTC) Controller Station to establish communication between one or two game controllers and the robot. You then can manipulate the behavior of the robot with the game controllers during TeleOperated mode.

Refer to Chapter 7, *Troubleshooting the Robot*, for troubleshooting tips if the robot does not work as you expect.

Downloading the Firmware

Before you can use the FTC Controller Station to control the robot, you must ensure that the FTC Controller Station can communicate with the NXT device. The NXT device must be running the correct firmware to communicate with the FTC Controller Station.

Downloading the Firmware from LabVIEW

Complete the following steps to download the correct firmware to the NXT device from LabVIEW. Ensure the NXT device is turned on and connected to the computer before you download new firmware to the device.

1. Launch LabVIEW.
2. Select **Tools»NXT Module»Update NXT Firmware** to display the **Update NXT Firmware** dialog box.
3. Click the **Browse** button next to the **Look in** text box to display a file dialog box.
4. Navigate to the `National Instruments\LabVIEW 8.5\vi.lib\addons\NXTToolkit\Firmware` directory and click the **Current Folder** button.
5. In the **Available Firmware Files** list, select **LEGO MINDSTORMS NXT Firmware v1.21**.

6. Click the **Download** button to begin downloading the firmware to the NXT device. The **Progress** section of the **Update NXT Firmware** dialog box displays the progress of the firmware update.
7. When the **Update NXT Firmware** dialog box displays **`Successfully Downloaded Firmware!`**, click the **Close** button to close the dialog box.

Downloading the Firmware from LEGO MINDSTORMS

Complete the following steps to download the correct firmware to the NXT device from LEGO MINDSTORMS. Ensure the NXT device is turned on and connected to the computer before you download new firmware to the device.

1. Launch LEGO MINDSTORMS.
2. Select **Tools»Update NXT Firmware** to display the **Update NXT Firmware** dialog box.
3. Click the **Browse** button to display the **Browse for Folder** dialog box.
4. Navigate to the `LEGO Software\LEGO MINDSTORMS Edu NXT\engine\Firmware` directory and click the **OK** button.
5. In the **Available Firmware Files** list, select **LEGO MINDSTORMS NXT Firmware v1.21**.
6. Click the **Download** button to begin downloading the firmware to the NXT device. The **Progress** section of the **Update NXT Firmware** dialog box displays the progress of the firmware update.
7. When the **Update NXT Firmware** dialog box displays **`Successfully Downloaded Firmware!`**, click the **Close** button to close the dialog box.

Connecting to the FTC Controller Station

After the NXT device has the correct firmware, you must connect the NXT device to the FTC Controller Station.

Note Refer to the *LEGO® MINDSTORMS® Education NXT User Guide* for information about using and configuring the NXT device.

Complete the following steps to connect the NXT device to the FTC Controller Station.

1. Navigate to the `National Instruments\LabVIEW 8.5\examples\FTC Toolkit\FTC Controller Station` directory or the `LEGO Software\LEGO MINDSTORMS Edu NXT\examples\FTC Toolkit\FTC Controller Station` directory and double-click `FTC Controller Station.exe` to launch the FTC Controller Station.

2. Click the **Run** button, shown at left, to begin running the FTC Controller Station. Notice that the FTC Controller Station automatically assigns any connected game controllers to **Controller 1** and **Controller 2**.
3. Enter the name of the NXT device in the **NXT Name** text box.
4. Click the **Connect** button to connect to the NXT device. The **NXT Name** text box is red when the NXT device is not connected, yellow while the FTC Controller Station is connecting to the NXT device, and green when the NXT device is successfully connected. When an NXT device is connected, the **Connect** button changes to either **Connect USB** or **Connect BT**, depending on whether the connection uses USB or Bluetooth.

   When the NXT device is connected successfully, the FTC Controller Station downloads two default programs, FTCTeleOp and Program Chooser, to the NXT device.

Selecting the TeleOperated Program

Use the Program Chooser program that the FTC Controller Station downloads to the NXT device to specify which program you want to run in TeleOperated mode. The Program Chooser program has two options, Single and Dual. The Single option indicates that you have only one program to run for both the Autonomous and TeleOperated modes. The Dual option indicates that you have separate programs to run in each mode.

If you select the Dual option, you must select the program you want to use in TeleOperated mode from a list of available programs on the NXT device. The Program Chooser program then creates an `FTCConfig.txt` configuration file that specifies the program you selected as the program to run in TeleOperated mode. When the mode of the robot changes from **Autonomous** to **TeleOperated**, the FTC Controller Station stops any currently running Autonomous program and starts running the TeleOperated program that the configuration file specifies.

If you select the Single option, the Program Chooser program does not create an `FTCConfig.txt` configuration file. If a configuration file already exists on the NXT device, the Program Chooser program deletes this file. Because no configuration file exists, the FTC Controller Station does not stop the currently running program when the mode of the robot changes from **Autonomous** to **TeleOperated**.

Complete the following steps to use the Program Chooser program to select the program you want to use in TeleOperated mode.

1. On the NXT device, navigate to **My Files»Software files»Program Chooser** and press the orange button.
2. Select **Run** and press the orange button.
3. Select **Dual** and press the orange button.
4. Use the left and right arrow buttons to select `FTCTeleOp.rxe` from the list of programs and press the orange button. The Program Chooser program creates an `FTCConfig.txt` configuration file on the NXT device that specifies FTCTeleOp as the program to run in TeleOperated mode.
5. Press the orange button to end the Program Chooser program.
6. In the FTC Controller Station, click the **Update** button to detect the `FTCConfig.txt` configuration file on the NXT device. Notice that the **FTCConfig.txt found on brick?** round LED turns green, and `FTCTeleOp.rxe` is listed as the **Designated TeleOperated Program**.
7. Set the **Mode** of the NXT device to **TeleOperated**. Because you specified a **Designated TeleOperated Program**, the FTC Controller Station stops any program running in Autonomous mode on the NXT device and begins running the **Designated TeleOperated Program**.

Note Notice that you also can set the **Status** of the robot from the FTC Controller Station. The FTCTeleOp program does not handle the Enabled or Disabled status to change the behavior of the robot. However, ensure that the programs you run on the NXT device for the FTC competition handle both an Enabled and a Disabled status. When the **Status** is **Disabled**, the robots must stop moving. Refer to the *Enabled and Disabled Status* section of Chapter 1, *Overview of the FIRST Tech Challenge*, for more information about the Enabled and Disabled status.

Using the Game Controllers

After you connect the NXT device to the FTC Controller Station and select the TeleOperated program you want to use, you can use game controllers to manipulate the behavior of the robot.

Complete the following steps to select the game controllers you want to use to manipulate the behavior of the robot.

1. Click the **Refresh List** button for **Controller 1**. An updated list of game controllers connected to the host computer appears in the text box above the **Refresh List** button.
2. From the list of connected game controllers, select the game controller you want to correspond to **Controller 1**. **Controller 1** now displays any movements or button presses you make on the physical game controller. For example, if you press button 2 on the game controller, button 2 on **Controller 1** appears to be pressed as well. The FTC Controller Station sends any game controller data for **Controller 1** to the FTCTeleOp program running on the NXT device, which manipulates the behavior of the robot accordingly.

Note Buttons 9–12 are not shown on **Controller 1** or **Controller 2** of the FTC Controller Station. Buttons 11 and 12 correspond to the left and right joystick buttons, respectively.

3. If you want to use two game controllers to manipulate the behavior of the robot, repeat steps 1 and 2 for **Controller 2**.
4. Move the joysticks on the game controller and observe how the robot responds.
5. Click the **STOP Program** button in the FTC Controller Station to stop both the FTC Controller Station and the program running on the NXT device.

5

Modifying the Program in LabVIEW

The FTCTeleOp program moves the motors of a robot according to joystick movements you make on a game controller. You can use LabVIEW to modify this program to perform more advanced tasks. For example, you can modify the program so that the robot moves at turbo speed when you press a button on the game controller.

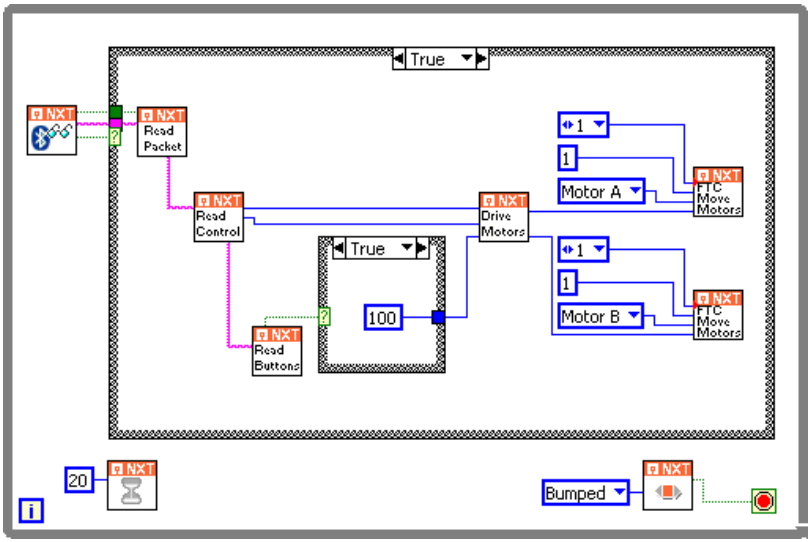
Complete the following steps to modify the FTCTeleOp program in LabVIEW and program a turbo button. Refer to Chapter 6, *Modifying the Program in LEGO MINDSTORMS*, to modify the FTCTeleOp program in LEGO MINDSTORMS.

1. Navigate to the `National Instruments\LabVIEW 8.5\examples\FTC Toolkit` directory and open `FTCTeleOp.vi` to open the source VI for the FTCTeleOp program.
2. Select **Window»Show Block Diagram** or press the <Ctrl-E> buttons to display the block diagram.
3. Place an FTC Read Buttons VI, located on the **FTC Toolkit** palette, on the block diagram inside the Case structure and under the FTC Read Controller VI and the FTC Drive Motors VI.
4. Wire the **Buttons** output of the FTC Read Controller VI to the **Buttons** input of the FTC Read Buttons VI. The FTC Read Buttons VI returns the Boolean values of the buttons on the controller whose data the FTC Read Controller VI reads.
5. Place a Case structure, located on the **Programming»Structures** palette, to the right of the FTC Read Buttons VI. Notice the selector terminal on the left border of the Case structure. The value you wire to this selector terminal determines which case of the Case structure to execute.

Note If you do not have enough room to place the Case structure, <Ctrl>-click the white space between the FTC Read Controller VI and the FTC Drive Motors VI and drag the mouse sideways to add more space between the two VIs.

6. Wire the **Button 1** output of the FTC Read Buttons VI to the selector terminal of the Case structure. When button 1 on the game controller is pressed, the **Button 1** output of the FTC Read Buttons VI returns TRUE, and the True case of the Case structure executes. When button 1 on the game controller is not pressed, the **Button 1** output of the FTC Read Buttons VI returns FALSE, and the False case of the Case structure executes.
7. Click the increment or decrement arrow of the selector label of the Case structure to switch to the False case.
8. Click the numeric constant with value 30 that is connected to the FTC Drive Motors VI and drag it inside the False case of the Case structure.
9. Rewire the numeric constant to the **Throttle** input of the FTC Drive Motors VI. When button 1 on the game controller is not pressed, the numeric constant in the False case specifies a throttle of 30, and the motors of the robot move at 30% speed.
10. Click the increment or decrement arrow of the selector label of the Case structure to switch to the True case.
11. Place a numeric constant, located on the **Programming»Numeric** palette, in the True case of the Case structure and set the value of the numeric constant to `100`.
12. Wire this second numeric constant to the output tunnel on the border of the Case structure. When button 1 on the game controller is pressed, the numeric constant in the True case specifies a throttle of 100, and the motors of the robot move at 100% speed. Thus button 1 of the game controller acts like a turbo button for the robot.

The block diagram of the VI should look similar to the following figure.



13. Save this program as `FTCTeleOpTurbo.vi` in an easily accessible location. You can compare this program to the `FTCTeleOpTurbo.vi` in the `National Instruments\LabVIEW 8.5\examples\FTC Toolkit` directory.
14. Follow the instructions in Chapter 4, *Controlling the Robot with the FTC Controller Station*, to specify FTCTeleOpTurbo as the program to run in TeleOperated mode. You then can move the robot using the joysticks on a game controller and use button 1 of the game controller as a turbo button.

6

Modifying the Program in LEGO MINDSTORMS

The FTCTeleOp program moves the motors of a robot according to joystick movements you make on a game controller. You can use LEGO MINDSTORMS to modify this program to perform more advanced tasks. For example, you can modify the program so that the robot moves at turbo speed when you press a button on the game controller.

Complete the following steps to modify the FTCTeleOp program in LEGO MINDSTORMS and program a turbo button. Refer to Chapter 5, *Modifying the Program in LabVIEW*, to modify the FTCTeleOp program in LabVIEW.

1. Navigate to the `LEGO Software\LEGO MINDSTORMS Edu NXT\examples\FTC Toolkit` directory and open `FTCTeleOp.rbt` to open the source for the FTCTeleOp program.
2. Place an FTC Read Buttons block, located on the **Data** block palette, on the work area between the FTC Read Controller block and the FTC Drive Motors block.
3. Wire the **Buttons** output plug of the FTC Read Controller block to the **Buttons** input plug of the FTC Read Buttons block.

Note If you do not see any data plugs for the FTC Read Buttons block, click the tab at the lower left edge of the block to display the data hub.

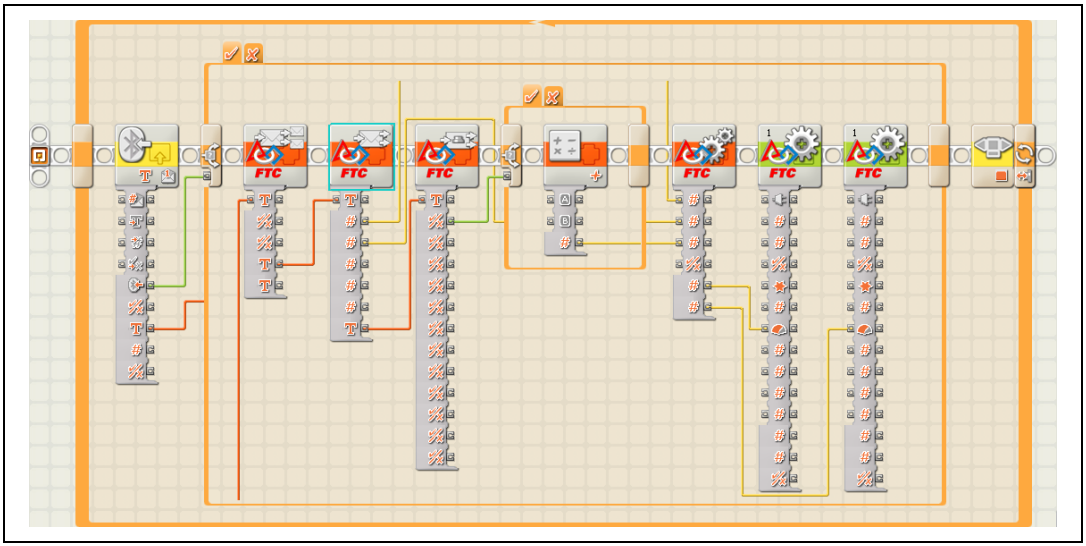
The FTC Read Buttons block returns the logic values of the buttons on the controller whose data the FTC Read Controller block reads.

4. Place a Switch block, located on the **Common** block palette, to the right of the FTC Read Buttons block.
5. In the configuration pane of the Switch block, set the **Control** property to **Value**. An input data wire plug appears at the bottom left corner of the Switch block. The value you wire to this input plug determines which case of the Switch block to execute.
6. Also in the configuration pane of the Switch block, remove the checkmark from the **Flat view** checkbox.

7. Wire the **Button 1** output plug of the FTC Read Buttons block to the input data wire plug of the Switch block.

   When button 1 on the game controller is pressed, the **Button 1** output plug of the FTC Read Buttons block returns TRUE, and the True case of the Switch block executes. When button 1 on the game controller is not pressed, the **Button 1** output plug of the FTC Read Buttons block returns FALSE, and the False case of the Switch block executes.
8. Click the X on top of the Switch block to switch to the False case.
9. Place a Math block, located on the **Data** block palette, in the False case of the Switch block.
10. In the configuration pane of the Math block, set the **B** property to 30.
11. Wire the **Result** output plug of the Math block to the **Throttle** input plug of the FTC Drive Motors block. When button 1 on the game controller is not pressed, the Math block in the False case specifies a throttle of 30, and the motors of the robot move at 30% speed.
12. Click the checkmark on top of the Switch block to switch to the True case.
13. Place a Math block in the True case of the Switch block.
14. In the configuration pane of the Math block, set the **B** property to 100.
15. Wire the **Result** output plug of this second Math block to the border of the Switch block, aligned with the wire connected to the **Throttle** input plug of the FTC Drive Motors block. When button 1 on the game controller is pressed, the Math block in the True case specifies a throttle of 100, and the motors of the robot move at 100% speed. Thus button 1 of the game controller acts like a turbo button for the robot.

The work area of the program should look similar to the following figure.



16. Save the program as `FTCTeleOpTurbo.rbt` in an easily accessible location. You can compare this program to the `FTCTeleOpTurbo.rbt` file in the `LEGO Software\LEGO MINDSTORMS Edu NXT\examples\FTC Toolkit` directory.
17. Follow the instructions in Chapter 4, *Controlling the Robot with the FTC Controller Station*, to specify FTCTeleOpTurbo as the program to run in TeleOperated mode. You then can move the robot using the joysticks on a game controller and use button 1 of the game controller as a turbo button.

7

Troubleshooting the Robot

In previous chapters, you built a robot whose behavior you can manipulate using a game controller. However, at times, the robot might not work as you expect. Table 7-1 describes common issues you might encounter when working with the robot and solutions to address those issues.

Table 7-1. Common Programming Issues

Issue	Solution
I cannot connect to the device using Bluetooth.	Shut down any programs running on the NXT device before you try using Bluetooth to connect to the NXT device. Ensure the NXT device is within range of the Bluetooth device. Bluetooth has a limited range of approximately fifty feet. Ensure Bluetooth is on and the Bluetooth icon is visible on the NXT device. If Bluetooth is on and visible but you cannot connect to the NXT device, try power cycling the device. Turn the device off, turn the device back on, and then try reconnecting to the NXT device using Bluetooth. You also might need to remove and reinsert the batteries in the NXT device before reconnecting to the device.
I try to run the program on the NXT device, but the robot is not responsive.	Ensure you have enough battery power on the NXT device. If you are using a rechargeable battery pack, ensure the battery pack is fully charged. The battery pack takes between five and six hours to charge. When charging is complete, the red light on the battery charger turns off. Ensure the NXT device is not in sleep mode. By default, the NXT device enters sleep mode after 10 minutes of inactivity. On the NXT device, you can set **Sleep** to **Never** to prevent the device from shutting down. Select **Settings»Sleep** and use the left and right arrow buttons to select **Never**. Then press the orange button on the NXT device. Ensure the game controllers are connected to the host computer. If you unplug a game controller, you must click the **Refresh List** button in the *FIRST* Tech Challenge (FTC) Controller Station and reselect the controller you want to use.

Table 7-1. Common Programming Issues (Continued)

Issue	Solution
I am trying to connect to the NXT device from the FTC Controller Station, but the FTC Controller Station cannot find the NXT device.	Connecting to the NXT device from the FTC Controller Station for the first time can take up to one minute. Subsequent connections take less time. Ensure you entered the correct name of the NXT device in the **NXT Name** text box in the FTC Controller Station. This field is case sensitive. Ensure the NXT device is not in sleep mode. By default, the NXT device enters sleep mode after 10 minutes of inactivity. On the NXT device, you can set **Sleep** to **Never** to prevent the device from shutting down. Select **Settings»Sleep** and use the left and right arrow buttons to select **Never**. Then press the orange button on the NXT device.
I accidentally unplugged a game controller but plugged it back in. Now the FTC Controller Station does not recognize the game controller.	Click the **Refresh List** button in the FTC Controller Station and reselect the controller you want to use.