



MINDSTORMS™

ROBOTICS INVENTION

SYSTEM™ 1.5

USER GUIDE

9747

Contacting LEGO® MINDSTORMS™ Technical Support:

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- For European support outside the United Kingdom,
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LEGO® MINDSTORMS™ ROBOTICS INVENTION SYSTEM™ 1.5 Computer Hardware Specifications

MINIMUM SYSTEM REQUIREMENTS

Operating System	Windows® 95/98
CPU	Pentium® 166
RAM	16 MB
Available Hard Disk Space	70 MB
Mouse	Windows® 95/98 Compatible
Available 9-Pin Serial Port For Infrared Transmitter	1
Sound	Sound Blaster 16™ Windows compatible Sound Device
CD-ROM Speed	CD 8x
Video Display	800 x 600 SVGA video, 1 MB ram
Colors	16 Bit Colors
Modem (Optional)	28.8 Kbps
Internet Browser (Optional)	Netscape® Navigator or Microsoft® Internet Explorer

Tested to comply with FCC Standards -
FOR HOME OR OFFICE USE.

FCC Statement:

This device complies with part 15 of the FCC Rules. Operation is subject to the following 2 conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received including interference that may cause undesired operation.

Warning:

Changes or modifications to the RCX or IR Transmitter not expressly approved by the party responsible for the compliance could void the user's right to operate the equipment.

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THE ROBOTICS INVENTION SYSTEM™

You hold in your hands a powerful new technology... the LEGO® MINDSTORMS™ Robotics Invention System™ 1.5. These building blocks of the future allow you to transform your dreams into reality.

With it, you can construct and program robots. Real robots. Your robots... and you can train them to move, act, and think on their own.

You can create everything from a light-sensitive intruder alarm to a robotic rover that follows a trail. You can even build a new friend.

But that's just the beginning, because you hold the future in your hands. You have the tools to build something that no one else has ever imagined.

With your LEGO MINDSTORMS Robotics Invention System, the line between science fiction and science fact is blurred. With LEGO MINDSTORMS, you make your own future... because you are the future of building.

LEGO MINDSTORMS™

The brain of the Robotics Invention System is the RCX, which stands for Robotics Command

System. The RCX is a microcomputer, built into a LEGO brick.

You can program it using your PC, or use one of its five built-in programs to control robots.



The RCX uses sensors (such as Touch and Light) to take input from its environment. It can then process the data to make motors turn on and off. With your LEGO

MINDSTORMS Robotics Invention System, you build robots that explore the world.

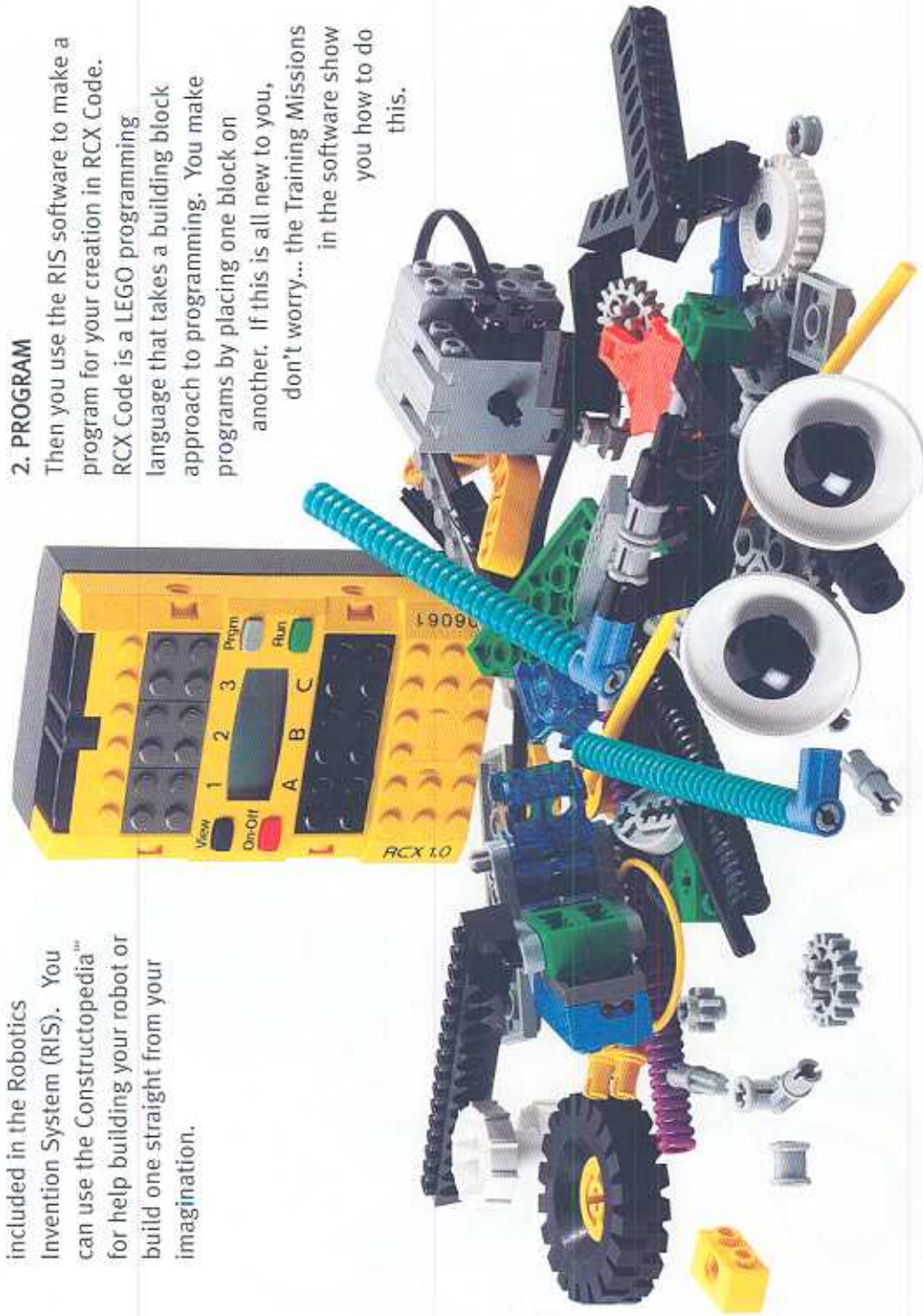


1. BUILD

First, you build your robot using the RCX and the LEGO pieces included in the Robotics Invention System (RIS). You can use the Constructopedia™ for help building your robot or build one straight from your imagination.

2. PROGRAM

Then you use the RIS software to make a program for your creation in RCX Code. RCX Code is a LEGO programming language that takes a building block approach to programming. You make programs by placing one block on another. If this is all new to you, don't worry... the Training Missions in the software show you how to do this.



3. TEST

Finally, you download your program to the RCX using the special infrared transmitter (IR Transmitter). Your robot is now able to move without the help of your computer...

...and you are ready to play with your creation.



QUICK START

- 1) With your PC turned off, add a 9-volt battery to the IR Transmitter. Then connect it (with the included cable) to a free serial/com port on your computer (see page 14 for detailed instructions).

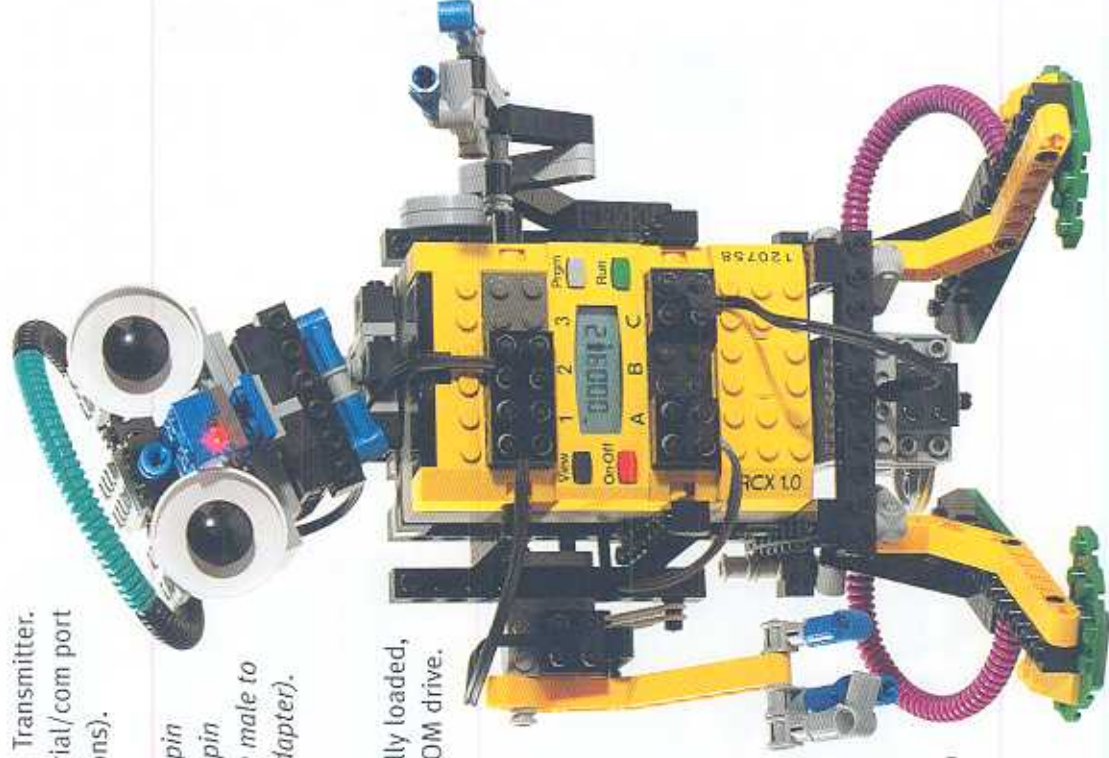
The IR Transmitter's cable plugs directly into a 9-pin male serial connector. If your computer has a 25-pin male connector, you will need to purchase a 9-pin male to 25-pin female adapter (also known as a mouse adapter).

- 2) Turn on your computer. When Windows 95/98 has fully loaded, insert the LEGO MINDSTORMS RIS CD into your CD-ROM drive. The installation screen of the RIS software should automatically be launched, so follow the on-screen directions to install the program.

If the installation screen does not automatically load, double-click your CD-ROM drive icon in the Windows Explorer®. Then double-click the Setup.exe program and follow the on-screen directions to install the program.

- 3) Once you have installed the software, you are taken through a series of activities. These "Guided Mode" activities will help you become familiar with the LEGO MINDSTORMS Robotics Invention System.

Advanced users: You can skip Guided Mode by holding down the Control key and clicking the About button in the Main Menu. If you want to see the beginning exercises again, just start as a new user.





RCX: THE BRICK

The RCX (Robotics Command System) is a programmable LEGO® brick. It has three sensor (input) ports, three output ports, four control buttons, an LCD display, and an infrared transmitter. It also has a microprocessor to process programs, internal memory to store firmware and programs, and a built-in speaker to produce beeps and tones.

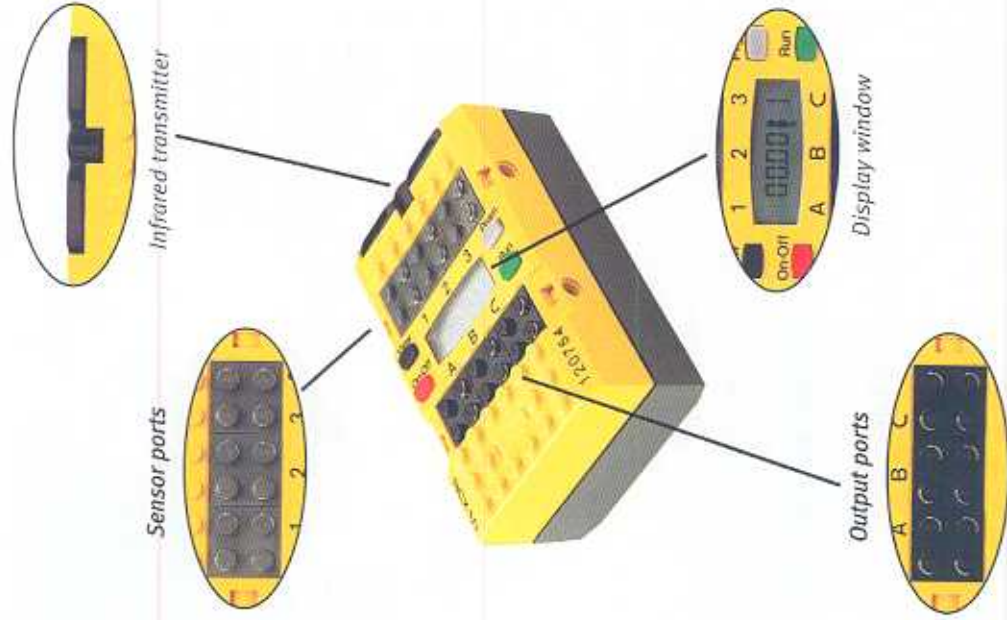
Being a LEGO brick, it has LEGO studs and holes to allow the connection of other LEGO bricks and pegs.

The sensor ports are used for attaching Light and Touch Sensors (as well as Rotation and Temperature Sensors, not included in this set).

The output ports are used for attaching motors (as well as lights and other output devices, not included in this set).

In addition, it has three internal sensors: a counter (to count events), a timer (to keep track of time), and an RCX message holder (to receive messages sent from other RCX units).

By programming the RCX to react to sensors, you create behaviors for your inventions... you make your robots smart.

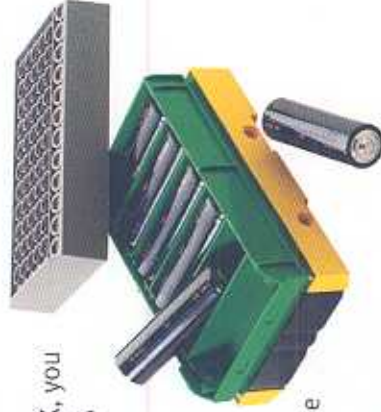




RCX: THE BATTERIES

Batteries

In order to use the RCX, you must insert six AA/LR6 batteries. Alkaline batteries are recommended. Rechargeable batteries can be used, but power may be reduced.



Instructions for use of battery box:

Never mix different types of batteries or old and new batteries in one battery box. Always remove the batteries from the battery box for long-term storage or if they have reached the end of their life. Liquid leaking from dead batteries will damage the RCX. Rechargeable batteries should be recharged under adult supervision.

Installation:

1. Make sure your RCX is turned off.
2. Remove the gray plastic battery cover.
3. Insert all 6 batteries. Make sure the "+" sign inside on each battery matches the "+" sign inside the RCX... all of the batteries go in the same way.
4. Put the battery cover back on.

Good to know:

When changing old batteries to new ones, switch them quickly. If it takes longer than one minute, your RCX's memory is cleared. This means that your firmware and programs are erased. If this occurs, just download them again from your PC.

Battery control with software

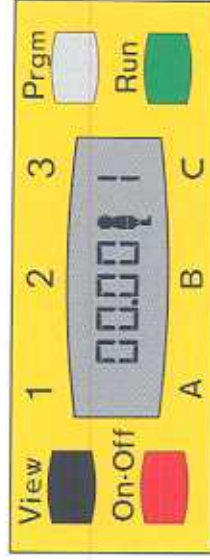
To save batteries, your RCX automatically shuts itself off after being left on for 15 minutes. However, it is possible by using Set Up Options in the Getting Started section (*Getting Started: Set Up Options*) of the RIS software, to change the "power down" setting to any time between 1 and 99 minutes... as well as infinity (which is forever, or at least until your batteries die).



You can also use the RCX battery status bar in *Getting Started: Set Up Options* on the software, to check how much power is left in your batteries.

RCX: THE BUTTONS

The buttons are used to control your RCX and its programs.



On-Off turns the RCX on and off. *The other three buttons only work when the RCX is on.*

Prgm (which stands for Program) allows you to switch between the five program slots in the RCX. The number of the selected program appears to the right of the “little person” in the display window.

Run starts and stops the selected program. In the “Run” mode, the “little person” in the display window appears to be running.

View (only active after firmware downloaded) allows you to get information on sensors and motors. You can see sensor readings at input ports 1, 2, or 3, and motor direction at output ports A, B, or C.

To use the **View** button to check a Touch (or Light) Sensor's reading:

1. Make sure you have downloaded a program that uses a Touch (or Light) Sensor and have run it at least once.
2. Make sure the Touch (or Light) Sensor is attached to a sensor port on your RCX.
3. Make sure the RCX is on.
4. Press the **View** button, so the arrow in the display window points to the port where the Touch (or Light) Sensor is attached.

For the Touch Sensor

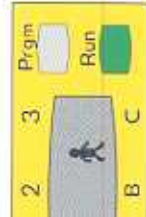
5. Press and release the Touch Sensor while looking in the display window. When the Touch Sensor is pressed, the number should be 1. When it is released, it should be 0.

For the Light Sensor

5. While looking at the display window, move the Light Sensor's eye back and forth over the black line on the Test Pad. The number will be low when it sees the black line, and high when it sees the white paper.

DISPLAY WINDOW

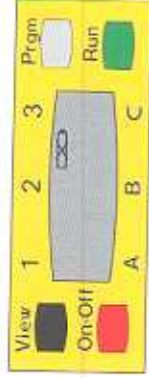
display window shows you information about the RCX and your programs.



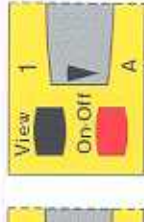
person" running at the RCX is program. The running when the pressed.



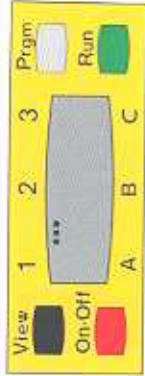
The number (1-5) appears to the right of the "little person." It indicates which of the 5 programs will be activated when the Run button is pressed.



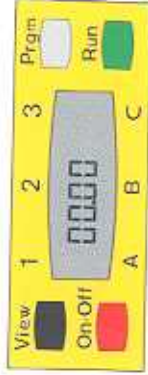
The battery-low indicator lights up when battery charge is low. It flashes and the RCX beeps when the battery charge is very low.



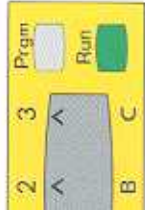
range infrared cone lights up indication between emitter and the RCX.



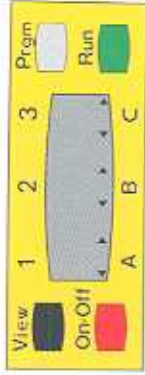
Dots light in sequence (one after the other) when a program is being downloaded from the PC to the RCX.



The Software Watch (only active after firmware downloaded) shows how many minutes the RCX has been on from last setting or resetting. Turning the RCX off and on, or downloading firmware again, resets the Watch.



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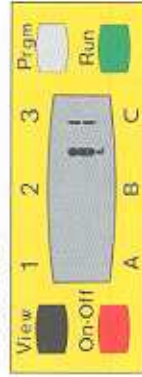
An arrow displayed above an output port indicates that the output port is active. The direction of the arrow shows the direction of a motor connected to the port.

THE FIRMWARE

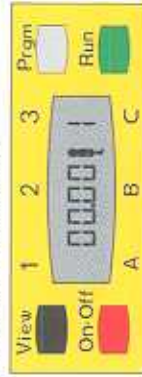
The first time your RCX is turned on, or after batteries have been switched (and it took you longer than one minute to change them), your RCX is in "Boot Mode."

You can see if your RCX is in Boot Mode by looking at the display window. If there is no Software Watch, it is.

Boot Mode



Full Function Mode



In Boot Mode, you cannot download programs to your robot because your RCX needs firmware. Firmware is special software that allows communication between your computer and the RCX to occur. It acts as the RCX's operating system.

However, if you are in Boot Mode and do not have access to a PC, or if you just want to play with your RCX right now, you can use any of your RCX's five built-in programs.



To download firmware to your RCX:

1. Run the Robotics Invention System™ 1.5 CD-ROM.
2. Click **Getting Started**.
3. Click **Set Up Options**.
4. Turn on your RCX and place it about 4-6 inches (10-12 cm) in front of the IR Transmitter.
5. Click the gray button to the right of "Download RCX firmware."

Downloading takes approximately 3 minutes. The Software Watch counts as the firmware is downloading and will beep when it is done. Do not switch off or move your RCX while downloading.

For more detailed instructions on downloading firmware, look at Getting Started: Set Up Part 2 on your RIS CD-ROM.





BUILT-IN PROGRAMS

There are five programs built into your RCX. You may overwrite (copy over) these programs with your own programs. Program slots 1 and 2 are locked by default, but you can unlock them in the *Getting Started: Set Up Options* section of your Robotics Invention System™ software.

Program 1

Purpose: Makes a robot beep and then move forwards.

How the program functions: When the program is run, the RCX beeps once. Then power is supplied to ports A and C causing the motors to turn and the robot to move forwards.



Program 2

Purpose: Controls a robot with two Touch Sensors. The robot moves forwards and turns to one side when one Touch Sensor is pressed. It turns to the other side when the second sensor is touched.

How the Program Functions: Power is supplied to ports A and C. The Touch Sensor, attached to port 1, controls the motor attached to port A. When the sensor is touched, power stops flowing to motor A causing the robot to turn. Touching port 3's Touch Sensor stops power from flowing to motor C which causes the robot to turn to the opposite side.

Program 3

Purpose: Robot moves forwards until its Light Sensor registers a change of light intensity (for example, when the robot reaches a dark colored surface). It then stops.

How the Program Functions: The Light Sensor attached to port 2, controls the motors attached to ports A and C. When the sensor detects light intensity (brightness) between 51-100%, power is supplied to ports A and C. When the sensor detects intensity between 0-40%, power is stopped.

Program 4

Purpose: Makes a robot move forwards and backwards five times, for a random length of time.

How the Program Functions: Provides power to output ports A and C and repeats the following sequence five times:

- reverses direction of output ports A and C,
- pauses program for a period between 0 and 3 seconds (motors A and C still turn),
- reverses direction to port A (turning robot),
- pauses program for 0 to 3 second (robot still turns),
- and reverses direction on port A again.

When sequence is done repeating, the robot stops.

Program 5

Purpose: Makes a robot move forwards and change its direction if it encounters an obstacle in its path. This program uses only one Touch Sensor.

How the Program Functions: Provides power to the motors attached to ports A and C. Each time the Touch Sensor (attached to port 1) is pressed, the following sequence occurs:

- reverses direction on output ports A and C,
- pauses program for 1 second (robot keeps moving)
- reverses direction on port A (turning robot),
- pauses 0.5 second (robot continues turning),
- and reverses direction on port C (both motors are now turning in the same direction).





IR TRANSMITTER

The IR Transmitter establishes a wireless link between your computer and the RCX. With the IR Transmitter, programs can be downloaded from your computer to the RCX. These programs can then be executed (run) by the RCX.



The IR Transmitter uses infrared signals to send messages.

For communication to occur, the RCX and IR Transmitter must be able to see each other. Even though 4-6 inches (10-12 cm) works best for downloading, in optimal lighting conditions, communication is still possible at distances up to 90 feet (30 meters) away.

Installation:

In order to use your IR Transmitter, you must first insert a 9-volt/6LR61 battery and then connect it to your computer. An alkaline battery is recommended.



Instructions for battery use:

Always remove the battery from the IR Transmitter for long-term storage or if it has reached the end of its life. Liquid leaking from a dead battery will damage the IR Transmitter. Rechargeable batteries should be recharged under adult supervision.

The Steps:

1. Slide battery cover down.
2. Insert battery, making sure the "+" sign matches the one inside the Transmitter.
3. Slide battery cover back up.
4. Connect one end of the cable to the IR Transmitter and the other end to your computer's com port (you must have a free serial/com port to do this).





The cable that comes with your LEGO® MINDSTORMS™ Robotics Invention System™ plugs directly into a 9-pin male serial connector. If your computer has a 25-pin male connector, you will need to use a 9-pin male to 25-pin female adapter (*not included*).

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There are two ranges of transmission available, short and long. Switching settings affects the distance at which the RCX and IR Transmitter can communicate with each other. To choose a setting, you must change the range on both the IR Transmitter as well as the software (software switch for the RCX located at *Getting Started: Set Up Options*).

IR Transmitter Range Switch



Short

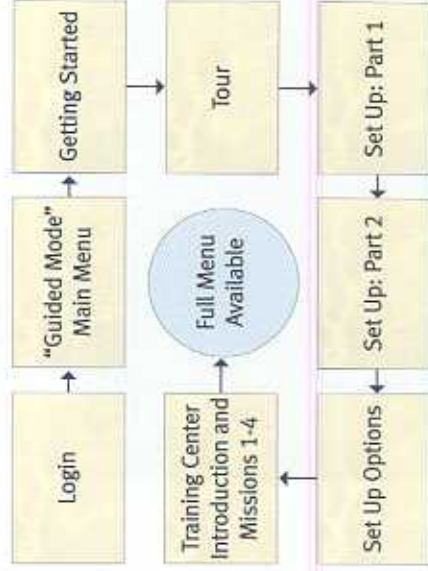
Long



GUIDED MODE



When you login as a new user, you are in "Guided Mode". Guided Mode takes you through the Robotics Invention System™ and shows you how it works.



Tip for advanced users: If you are already familiar with the Robotics Invention System, you can bypass the Guided Mode, and make all menus active, by holding down the Control key while clicking the About button in the Main Menu. To make the Guided Mode active again, you need to login with a different user name.

RCX CODE



In RCX Code (located in *Program RCX:RCX Code*), you build programs by stacking graphical blocks. These computer images fit together like LEGO® bricks.

RCX Code is the special programming language for the Robotics Invention System. In it, each block on the computer screen represents one instruction (or command).

In RCX Code, you make a program that tells your RCX what you want it to do. You decide how you want your robot to act and react, then you build a program to make it do that. After you download the program to the RCX, it is inside your robot and able to control it. For example, to make your robot move, you can build and then download a program that turns on your robot's motors.



When using Sensor Watchers, your program will have more than one stack. Like a single stack program, it starts at the first block (the Program block), and works its way down.

However, when the Sensor Watcher finds what it is looking for, the program will simultaneously (at the same time) work its way down the Sensor Watcher's and the Program block's stacks.

Tip: If your program grows larger than the computer screen, you can move the pointer to the edge of the screen to bring the off-screen areas into view.

RCX CODE BLOCKS

The following is an explanation of RCX Code blocks. For a description of individual blocks, see the *Help:RCX Code Reference* on the RIS CD-ROM.



The Program block is the beginning (first block) of every RCX Code program. By right-clicking the Program block, you flip it over and can then save, clear, or download the program. When saving a new program, click **Save as** and follow the on-screen instructions. To un-flip the Program block, click the green checkmark (Accept box).



Note: Before downloading a program to the RCX, click the arrows to select a

program slot (program slots P1 and P2 are locked by default, but you can unlock them in *Getting Started: Set Up Options* section). If “overwrite” is checked, your new program will be downloaded to the slot you choose. However, if “overwrite” is not checked, your program will be downloaded to the next unlocked slot.

commands

Command blocks are instructions that tell the RCX what to do; they execute commands. For example, Command blocks can make a sound, turn on motors, wait, as well as reset the counter.

Right-clicking the green Command blocks (except for Reset Counter, Reset Message, and Reset Timer) will flip the blocks over. When flipped, you can change the blocks' information, such as port to be activated, length of activation, or tone to be played.

sensor watchers

Sensor Watchers watch for, and react to changes in a

robot's environment. They monitor the readings of sensors and cause an attached stack to run when specific conditions are met. For example, a Touch Sensor Watcher can have a stack that makes the robot reverse when the Touch Sensor hits a wall.

Clicking the button in the upper left corner allows you to resize the Sensor Watcher block.

stack controllers

Stack Controllers allow you to control the way parts of your program run. You can cause part of your program to loop (repeat itself), as well as have some blocks that only run when certain sensor conditions are met. For example, a Repeat While block can make a Tone block repeat itself for as long as a Touch Sensor is pressed.

Clicking the button in the upper left corner allows you to resize the Stack Controller block.

My Commands

My Commands are the blocks that you make. They are programming shortcuts that help you keep your programs organized and efficient. You can replace a long stack of commands with a single block, and then use that single block again and again. In addition to saving time,

RCX CODE TOOLS

These tools are useful when programming in RCX Code.



The Try-out tool is helpful for testing the way an RCX Code block will work with your robot. To use it, make sure your RCX is on and in range of the IR Transmitter. Then click the **Try-out tool** and a code block in your program. To cancel the Try-out tool, right-click the mouse or press escape. Warning: your RCX may start moving, so make sure it is not close to the edge of a table.

you make sure that a portion of your program always runs the same way.

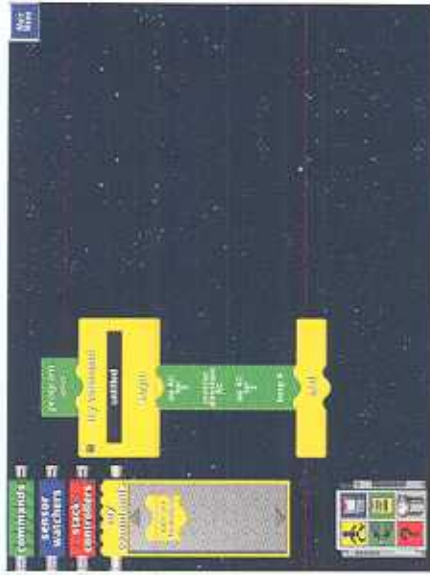
To create your own My Command block, drag a “New My Command” block from the My Commands container. Then place a program (or stack) you have created between the “begin” and “end” blocks of the “New My Command” block. To give your block a name, click “untitled” and type in a new name. When you save your program, your My Command block is saved in the My Commands container. It can then be used in other programs.

Clicking the button in the upper left corner allows you to resize the My Command block.

Clicking Command blocks send commands directly to the RCX and causes your RCX to run that block (for example, clicking a Tone block causes the RCX to play that tone). Clicking Sensor Watchers shows the attached sensor’s reading (for example, how much light the Light Sensor sees).



The Copy tool makes duplicating a block (or blocks) in your program easy. To use, click the **Copy tool** and then click the block (or blocks) you want to copy. The block you click, in addition to all blocks below it, is/are copied. To drop it/them, click where you want the block(s).





The Help tool gives you information on code blocks. To use, click the **Help tool** and then a code block (for example, a Touch Sensor Watcher block) to learn how it works. To cancel the Help tool, right-click the mouse or press escape.



The Program Vault icon lets you save or open a program by taking you to the Program Vault. Once there, you can open, delete, rename, save and organize your programs. To use, click the **Program Vault icon**.

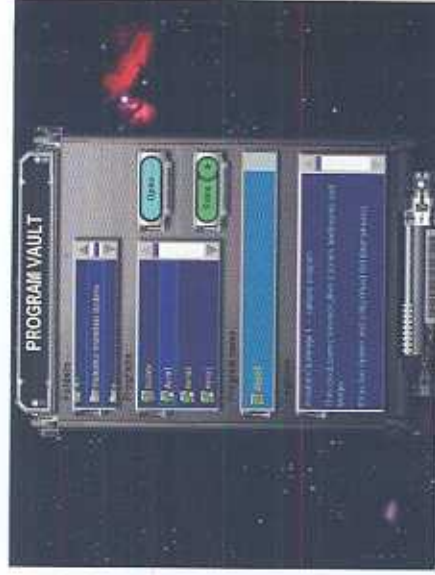


The Download/Save button flips the Program block and allows you to save, download, and clear programs. It has the same effect as right-clicking the Program block. To use, click the **Download/Save button**.



The Trash is used to delete RCX Code blocks. To use, click and drag a program block(s) to the Trash. Once blocks are trashed (deleted), they cannot be retrieved.

THE PROGRAM VAULT



Like a bank's safe, the Program Vault allows you to save your valuables for future use. In addition to using the Program Vault to save programs, you use it to open, delete, rename, and organize your programs.

Saving a program

When you click **Save** as from the back of the Program block on the RCX Code screen, you are taken to the Program Vault.

In the Program Name window, type in a name for your program. Then click in the Logbook window and enter a name for your robot, as well as a description of your program and the robot it controls.

It is always a good idea to write a little information in your logbook. It helps you remember what your program does.

When you save your program, it is saved in the folder highlighted in the Folders' window. To save it in another folder, the desktop, or a floppy disk, click on the appropriate item in the Folders' window.

To save your program, click the **Save** button.

To leave the Program Vault without saving your program, click the **Cancel** button.

Opening a program

To access a program, click on the folder the program is in (in the Folders' window), click on the program (in the Programs' window), and then click the **Open** button. Instead of using the **Open** button, you can also double-click the program's icon. When the program is opened, you are taken back to the RCX Code screen.

Organizing Programs

If you want to move a program from one folder to another, click and drag the program (from the Programs' window) to the folder (in the Folders' window) you want it to be in. To see programs in another folder, click on the folder in the Folders' window.

If you want to delete a program, drag it to the Trash (the last folder in the Folders' window). If you change your mind, just open the Trash and drag the program to another folder.

However, the Trash folder is automatically emptied every two days. When it is emptied, all of its contents are permanently destroyed.

To leave the Program Vault without opening a program, click the **Done** button.

Note: The built-in programs and Challenge files in the Robotics Invention System folder are locked: you cannot rename, move, or delete them. However, you can open these files and then use **Save as** (on the back of the Program Block) to save them as your own programs in your own folder.



WWW



The LEGO MINDSTORMS website is an internet community of robotic beginners and experts; a place where you share your expertise, as well as learn from other robots/users. At the website, you can also register your Robotics Invention System.

Note: Your Online Community membership card is enclosed in the set. On this card, you will find your exclusive membership number which you will need when you log on for the first time.

To help you develop your ideas, the LEGO® MINDSTORMS™ Online Community is provided on the Internet at www.legomindstorms.com.

Clicking the WWW button launches your computer's web browser. If you do not have a browser installed, clicking the button has no effect. You also need an internet connection.

At www.legomindstorms.com, you can create your own home page to display pictures of your robotic creations. You can also upload your RCX Code programs, as well as download the programs of others.

You can talk to other users, swap strategies, and post your own building ideas on message boards. There are also on-line tutorials to help you master programming and building tasks. In addition, new challenges are made available throughout the year.

You can also buy additional sensors and motors on the web at the LEGO store (www.legoworldshop.com). In addition to buying an extra part, you can buy a Temperature Sensor, a Rotation Sensor, as well as a Remote Control for your robot, and expansion sets.





A: TROUBLE SHOOTING

A more detailed trouble shooting section is included in the Robotics Invention System™ CD-ROM. To access the utility from the computers desktop, click the **Start menu** button. Then locate the Trouble Shooting program that is inside the LEGO Mindstorms:Robotics Invention System folder. You will also find the Read Me document in that folder which contains more information.

If you cannot download programs and/or Firmware to your RCX, make sure you have correctly inserted good batteries into both your IR Transmitter and your RCX.

Also make sure:

- your RCX is turned on
- your RCX is 4-6 inches (10-12 cm) away from, and facing, the IR Transmitter
- your IR Transmitter is firmly connected to COM1, COM2, COM3 or COM4 of your computer (Test that communication with COM1, COM2, COM3 or COM4 is working in *Getting Started:Set Up Options*)
- your IR Transmitter and software (*Getting Started:Set Up Options*) are set to long range

Note: If there is another RCX nearby, try switching the IR Transmitter as well as the software setting

(*Getting Started:Set Up Options*) to short range

- you avoid infrared signals from other IR devices, such as TV & VCR remote controllers, computers with IR communication ports
- the RCX and IR Transmitter are shielded from strong light. Avoid direct sunlight. Fluorescent lights can also cause problems
- the RCX and IR Transmitter are away from strong electric field sources, such as TV tubes and laptop TFT displays.

If your RCX is not working, make sure you have correctly inserted good batteries and that your RCX is turned on.

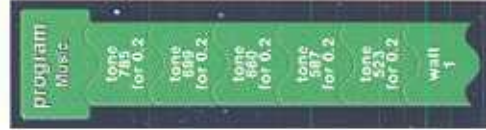
If you are having trouble with sensors and/or motors, make sure:

- the motor(s) and/or sensor(s) are attached firmly
- the motor(s) and/or sensor(s) are wired correctly (refer to Constructopedia, pages 4-5)
- the motor(s) and/or sensor(s) are plugged into the port(s) selected in your program
- if you are using a Sensor Watcher block in your program, that the necessary sensor reading is reached. For example, if the Light Sensor is set to check for 0-50, does the sensor ever show a reading between 0 and 50?

If you are having trouble with the software, reboot your computer and restart the program. If the program continues to have problems (such as it being unable to locate resources) you may need to reinstall the program. To reinstall the program, insert the RIS CD into your computer. When the introduction window appears, click **Reinstall**. If this window does not appear, open the contents of the CD and double click **Autorun**, then click **Reinstall**.

B: ADVANCED PROGRAMMING

Up to five programs can be stored in your RCX. Each program can have up to 9 different stacks which are executed simultaneously (multi-tasking); a stack is either the Program block stack or a Sensor Watcher stack. Within the RCX, only one program can be active at a time. Programs on the same RCX cannot control one another, nor can they be linked.



Music

For every five Tone blocks in a program stack, you need to include one Wait block with the total time of the five Tone blocks. For example, place a Wait block of 1.0 second after five Tone blocks that each have play time of 0.2 seconds.

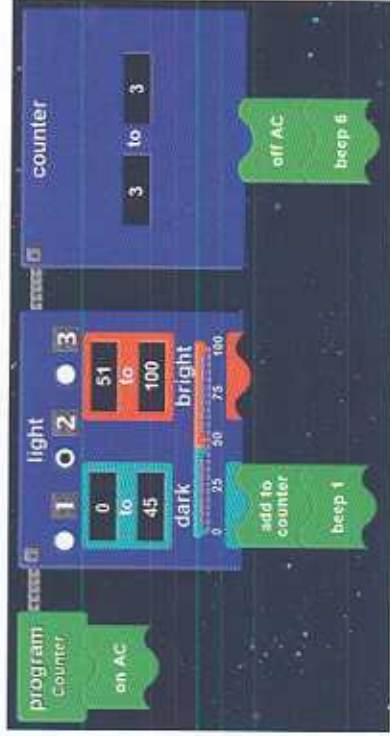
This chart shows the frequencies that correspond to specific notes

	Very Low	Low	Middle	High	Very High
C	131	262	523	1047	2093
C#	139	277	554	1109	2217
D	147	294	587	1175	2349
D#	156	311	622	1245	2489
E	165	330	660	1320	2640
F	175	350	699	1398	2797
F#	185	370	741	1482	2963
G	196	392	785	1570	3140
G#	208	416	832	1663	3326
A	220	440	880	1760	3520
A#	233	466	932	1865	3729
B	247	494	988	1976	3951

of the musical scale. To make music, enter the appropriate frequency number in the tone field of a Tone block.

Counter

The Counter Sensor Watcher is used to watch the counter. It is used with the Add to Counter block to count events. In the following example, the Counter is used with a Roverbot (Light Sensor pointing down) and a Test Pad. With the program downloaded to the RCX, the Roverbot is placed at the long end of the black ring (on the Test Pad), and Run is pressed.



The Counter Sensor Watcher is set as 3 to 3 so the Watcher only looks for the number 3.

When a green box (on the Test Pad) is driven over, the Light Sensor Watcher adds one to the counter and beeps. The Counter Sensor Watcher waits for the counter to equal three (for three green boxes to have been driven over). It then stops the Roverbot and beeps.

Communication between two or more RCX units

An RCX can send a message through its internal infrared transmitter to a second RCX. If the second RCX is in range, it will receive the message and then be able to react to this message.

To communicate, you must have at least one RCX set up (programmed) to work as the Sender and at least one as the Receiver. The Sender RCX must have a Send to RCX Command block in its Program stack. The Receiver RCX needs an RCX Sensor Watcher block.



The following example is for two robots. The Sender RCX has a Touch Sensor attached to sensor port

1. Each time its Touch Sensor is pressed, it plays a short tone and sends RCX message number 1.

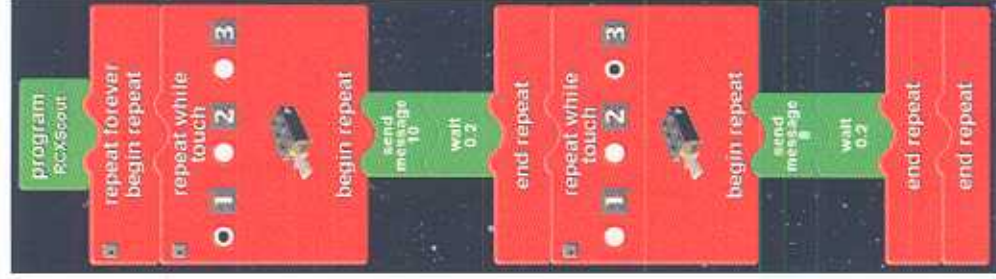
The Receiver RCX waits for the RCX message number 1 to be sent. After it receives the message, it plays a short tone.



For communication to work, you must press Run on both RCXs.

Communication between the RCX and the LEGO® MINDSTORMS™ Robotics Discovery Set™
 Though it is not possible to download RCX Code to a Scout™ (from the Robotics Discovery Set), it is still possible to control the Scout with an RCX. In this example, an RCX with two Touch Sensors and the Scout's Bug model is used. For the following RCX Code program to work, the Scout's Motion must be set to Forward.

When the Touch Sensor attached to the RCX's port 1 is touched, Send Message number 10 is sent and the Scout turns left. When the Touch Sensor attached to the RCX's port 3 is touched, Send Message number 8 is sent and the Scout turns right. The Wait blocks of 0.2 seconds are necessary to give the RCX the time to send the message to the Scout.



For the program to work, you must press Run on both the RCX and the Scout.

Note: When the Scout is running in stand alone mode, it is constantly waiting for Messages from the RCX.

Message Effects:

- 1: Seek dark
- 2: Seek light
- 3: The Bug dance
- 4: Forward (A Fwd, B Fwd)
- 5: Reverse (A Rev, B Rev)
- 6: Spin right (A Fwd, B Rev)
- 7: Spin left (A Rev, B Fwd)
- 8: Turn right, forward (A Fwd, B Off)
- 9: Turn left, reverse (A Rev, B Off)
- 10: Turn left, forward (A Off, B Fwd)
- 11: Turn right, reverse (A Off, B Rev)
- 12: Stop (A Off, B Off)

Messages 4-12 control the Scout for half a second, then the Scout returns to its original motion. The RCX's motor control overrides the Scout's default motion. However, if a sensor event or a special effect takes place in the Scout, it interrupts the RCX's Message controlled motion.

Programming without RCX Code

To program your RCX without using RCX Code, go to www.legomindstorms.com/sdk and get the document called SDK (Software Developers Kit). SDK gives a description about how the PC Driver (spirit.ocx) works. SDK also describes all of the commands the RCX can use (some of these commands are not available in RCX Code), as well as examples of how to program the RCX from Visual Basic.



C: GLOSSARY

Block - A graphical representation of an RCX Code command, Stack Controller, Sensor Watcher, or My Command. They fit together like jigsaw puzzle pieces to build a program.

Challenges - There are 12 challenges in the RIS set. They are open-ended and can be solved in many ways, but each challenge has an observable outcome. Challenges are used to help the user develop robot skills, as well as challenge their mind.

Com port - A port for connecting and communicating with external devices such as modems and IR Transmitters (also known as a serial port).

Commands - RCX Code blocks that execute an event and in turn makes the robot perform a function (i.e., do something).

Downloading - The process of transmitting (sending) an RCX Code program, as well as firmware, from the IR Transmitter to the RCX.

Firmware - The special software that allows communication between your computer and the RCX to occur. It acts as the RCX's operating system.

IR Transmitter - The device attached to the PC that communicates with the RCX.

My Commands - RCX Code blocks made by the user; programming shortcut which the user saves part of their program in a single block. The block can be reused in other programs.

Output Port - Any one of the three black studded plates on RCX to which an output device, such as a motor, can be attached.

Program - The stack of RCX Code blocks below the Program block, together with all the Sensor Watcher stacks, that makes a robot act and react. The Program block and all Sensor Watchers are executed simultaneously (at the same time).

Program Vault - The section of the RIS software that allows the user to store and retrieve RCX Code programs. It also allows the user to enter descriptions about his/her programs and robots, acting as a logbook.

RCX (Robotics Command System) - The programmable LEGO brick which is able to store and execute programs downloaded from a PC. Each RCX has three output, as well as three sensor ports.

RCX Code - The graphical computer language that uses blocks for creating RCX programs. The programs are downloaded to the RCX which in turn controls the robot it is built into.

RIS - The LEGO® MINDSTORMS™ Robotics Invention System™.

Sensor - There are two types, the external (outside) and the internal (inside). An external sensor is a LEGO brick that can be attached to a sensor port on an RCX to sense a change in its environment. Examples are the Light and Touch Sensors. The internal sensors are the Counter, the Timer, and the infrared receiver.

Sensor Port - Any one of the three gray studded plates on RCX to which an external sensor can be attached (also known as an input port).

Sensor Watchers - RCX Code blocks that monitor (watch) internal and external sensors for an event to occur. When the event occurs, the attached stack is executed (run). The Sensor Watcher stacks are executed simultaneously (at the same time) with the main program.

Stack - A sequence of RCX Code blocks attached one below the other. Stacks are executed sequentially (run from the top to the bottom).

Stack Controller - RCX Code blocks that use input sensors, timers or counter levels to control the execution of one or more command stacks.

Trouble Shooter - A tool in the LEGO MINDSTORMS Robotics Invention System software that can be launched when a problem occurs, usually with RCX communications. It provides help and guidance with fixing a problem. An abbreviated version of it is located in the User Guide.



LEGO MINDSTORMS™

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