

## Additional Information

### Programming Language

For those who are interested in using more advance sensory and programming. Here are some of the links to other programming languages and ready made sensors you can use for the LEGO MINDSTORMS system.

### Different programming languages available for LEGO® Mindstorms® NXT:



## NXT Programming Software

These are different ways of writing programs that will execute on the LEGO NXT brick. This list doesn't include all features, but should include enough information to provide a good starting point for you to figure out which software best suits your needs.

Features	NXT-G Retail	NXT-G Educational	RoboLab 2.9	NBC	NXC	RobotC	NI LabVIEW Toolkit	leJOS NXJ	pbLua	LEJOS OSEK		
Version	-	-	-	-	-	-	-	-	-	-		
Language type	Graphic	Graphic	Graphic	Assembly	(not exactly) C	C	Graphic	Java	Lua	ANSI C		
Firmware	Standard	Standard	Standard(#1)	Standard	Standard	Standard(#1)	Standard	Custom	Custom	Custom		
IDE	Yes	Yes	Yes	Yes	Yes	Yes	No	plugin	No	Eclipse		

(include d?)							(#6)	s for Eclips e and NetBe ans.	(#7)	CDT(GCC +ATMEL SAM-BA)	
Windo ws	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (#7)	Yes	
Mac OSX	Yes	Yes	Yes	Yes	Yes	Not Yet	Yes	Yes	Yes (#7)	No	
Linux	No	No	No	Yes	Yes	No	No	Yes	Yes (#7)	No (maybe)	
Events	No	No	Yes	No	No	Yes	No	Stand ard Java events		Yes (OSEK RTOS)	
Multith reading	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes (OSEK RTOS)	
Bluetoo th Brick to PC	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Bluetoo th Brick to Brick	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Not yet	
Bluetoo th Brick to Other Device	No	No	No	No	No	Yes	No	Yes	Yes	No	
I2C Support	(#5)	(#5)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (US only)	
RS 485 support	-	-	-	-	-	-	-	-	-	-	
File System	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not Yet	Not planned	
Floating Point	No	No	Yes	No	No	Yes	No?	Yes	(#8)	Yes	
Datalog	No	No	Yes	No	No	Yes	No	Yes	No	Not Yet	
How to get it	<a href="#">Inclu ded With retai</a>	<a href="#">Availabl e with Educati onal</a>	<a href="#">Availabl e with Educati onal</a>	<a href="#">BricxC C Web Site</a>	<a href="#">BricxC C Web Site</a>	<a href="#">RobotC .net or LEGO Educati</a>	<a href="#">LabVIEW W toolkit Site (#</a>	Free downl oad	<a href="#">pbLua Site</a>	<a href="#">LEJOS OSEK site</a>	

	<u>L</u> <u>versi</u> <u>on of</u> <u>NXT</u>	<u>Version</u> <u>of NXT</u>	<u>Version</u> <u>of</u> <u>NXT</u>			<u>on</u>	6)	<u>from</u> <u>lejos</u> <u>Web</u> <u>Site</u>				
<b>Support for 3rd party devices</b>	Yes	Yes	?	?	Yes	Yes	?	Yes	?	?		
<b>What do you want to do... (#2)</b>												
Make robots move without learning to program	Yes	Yes	Yes									
Learn to Program using the NXT				No								
Write "Fast" program s				Yes	Yes	Yes		Maybe ?	Yes	Yes		
Write program s "Fast"	Yes	Yes	Yes									
Learn Advance d Program ming concepts				?	Yes	Yes	Yes	Yes	Yes	Yes		
<b>Suited For (#3)</b>	Peo ple start ing with the NX T- or	School s starting with the NXT	School s upgra ding from the RCX to the NXT	Advan ced progr amme r	C progr amme r	Applic ations requiri ng maxim um speed	LabVI EW users, or people wantin g to improv e	Java Progra mmers	Educa tional Users	Embedded software programm er, C/C++ programm er		

	doin g sim ple task s						NXT- G			
	<b>NX T- G Ret ail</b>	<b>NXT- G Educ ationa l</b>	<b>Robo Lab 2.9</b>	<b>NBC</b>	<b>NXC</b>	<b>Robo tC</b>	<b>NI LabV IEW Toolk it</b>	<b>leJO S NXJ</b>	<b>pbLu a</b>	<b>LEJOS OSEK</b>
<b>Test Program (#4)</b>										
<b>Tested Version</b>	1.1	2.9							13c	
<b>Speed (loops/ min)</b>	762	73k		4285	103k	750/53 50 (#9)			18k	2695
<b>Speed (#10)</b>					134k/4 12k				31k	334k/1814 4k
<b>Memor y (bytes )</b>	10704 bytes	559 bytes		1428 Bytes	561 bytes	8084/1 890			1750 bytes	18240 (includes firmware)
<b>Time to write</b>	10 minutes	~20 min		30 minut es	30 min	15 min/80 min				30 minutes
<b>Progra m</b>	<u>Code, Graphic</u>	<u>Code, Graphi c</u>		<u>Code</u>	<u>Code1, Code2, Author' s comme nts</u>	<u>Code, Graphic / Code1 + Code2, Graphic</u>			<u>Code 1</u> <u>Code 2</u>	<u>Code</u>
<b>Other Comme nts (Facts &amp; Opinion s)</b>	This soft war e is desi gne d for kids	Same as Reta il version , with differe nt "Acade my"	LEGO has said this is the last versio n of Robo				Can be used to create blocks that work in NXT- G		Early in develo pment	LEJOS OSEK is NOT part of the leJOS project, but does use parts of

	, but is not too limiting for adults	robots.	Lab that will be made.				programs, <b>O</b> <b>R</b> it can create programs to download directly to the NXT <b>OR</b> it can create PC programs to control the NXT(s ee below)			leJOS code.		
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## Notes

- (1) RoboLab and RobotC both use firmware that comes Standard with some LEGO software.
  - (2) **None** of these are the "**Final Answer**" in programming, but maybe this will help you pick the right software for you.
  - (3) This is mostly an opinion of who would use this software.
  - (4) I created a "[test program](#)" to run on all platforms to compare speed, memory used (size of program), and approximate time to code the program, in the given language.
  - (5) The standard firmware does provide I2C functions, and NXT-G does use them for the Ultra-sonic sensor, but NXT-G does not provide direct access to I2C functions.
  - (6) The LabVIEW Toolkit for the NXT is an add-on for LabVIEW. In order to use it, the user must own a copy of LabVIEW.
  - (7) Programs are compiled on the LEGO NXT brick
  - (8) Lua supports something close to floating point. Check the web site for details
  - (9) The two NI programs were written using (1) The Labview Toolkit & high-level calls (kid proof blocks) and (2) The Toolkit and low level elements
  - (10) Most software will run faster if it is optimized, by minimizing, or removing the display commands. This row is has optimized speeds.
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## Software Suggestions

If you're looking here to find the "best" software, it's not that easy. The **best** software depends on what you want to learn, what you already know, and what you want to do. Even these questions are not always that clear-cut.

## NXT Off-Brick controllers (Remote Controls)

These are different types of "remote control" systems for the NXT. Most don't require any programming on the NXT. Generally, these allow someone to write and execute a program on a PC, which will send commands to the NXT, and in some cases, display the sensor values on the PC. This list rapidly grew beyond the width of a page, so it was turned to accommodate more languages

Software	Language type	Control type	NXT Required Firmware	Link Type	Link Source	Windows	Mac OS X	Linux	Read Sensors	Websites
<b>LEGO NXT Mobile Application</b>	Simple RC	Remote Control	Standard (#2)	Bluetooth	Phone or PDA	-	-	-	No	<a href="#">LEGO</a>
<b>FunkNXT</b>	Simple RC	Remote Control	Standard	Bluetooth	Phone	-	-	-	Yes	<a href="#">FunkNXT</a>
<b>BT RC</b>	NXT-G	NXT to NXT Remote	Program running on NXT	Bluetooth	Another NXT	-	-	-	User Programmable	<a href="#">BTRC</a>
<b>Simple BT Remote</b>	Simple RC	Remote Control	Standard	Bluetooth	Desktop	Yes	No	No	Yes	<a href="#">Simple Windows RC</a>
<b>RobotC</b>	Simple RC	Remote Control	Standard (#1)	USB/BT	Desktop	Yes	No Yet	No	Yes	<a href="#">RobotC Web Site</a>

<b>BricxC C</b>	Simple RC	Remote Control	Standard	USB/BT	Desktop	Yes		No	Yes	<a href="#">BricxCC Web Site</a>
<b>OnBrick PDA</b>	Graphic	Programmable RC	Standard	Bluetooth	PDA	-	-	-	Yes	<a href="#">OnBrick</a>
<b>OnBrick PC</b>	Graphic	Programmable RC	Standard	Bluetooth	Desktop	Yes	No	No	Yes	<a href="#">OnBrick</a>
<b>NXT Director</b>	Simple RC	Customizable Remote Control	Standard	Bluetooth	Palm PDA	-	-	-	No?	<a href="#">Director</a>
<b>RoboDNA</b>	Simple RC	Remote Control	Standard	Bluetooth	Desktop	Yes			Yes	<a href="#">RoboDNA</a>
<b>MS Robotics Studio</b>	.NET	User Program running on PC	Standard	Bluetooth	Desktop	Yes			Yes	(non-commercial version is free) <a href="#">Download site</a> or <a href="#">Microsoft Site</a>
<b>NI LabVIEW Toolkit</b>	Graphic (LabVIEW G)	User Program running on PC	Standard	USB/BT	Desktop	Yes	Yes		Yes	<a href="#">LabVIEW toolkit Site</a>
<b>RoboLab</b>	Graphic	User Program running on PC	Standard	USB	Desktop	Yes	Yes		Yes	<a href="#">Robolab</a>
<b>iCommand</b>	Java	User Program running on PC	Standard	Bluetooth	Desktop or PDA	Yes		Yes	Yes	<a href="#">iCommand</a>
<b>LEGO::NXT</b>	Perl	User Program running on PC	Standard	USB/BT	Desktop	Yes	Yes	Yes	Yes	<a href="#">Perl</a>
<b>nxt-Ruby</b>	Ruby	User Program running on PC	Standard	Bluetooth	Desktop	Yes	Yes	Yes	Yes	<a href="#">Ruby</a>
<b>NXT#</b>	C#	User	Standard	Bluetooth	Desktop	Yes			Yes?	<a href="#">NXT#</a>

		Program running on PC	rd	ooth	top					
<b>Mindsqualls</b>	C#	User Program running on PC	Standard	Bluetooth	Desktop	Yes			Yes	<a href="#">Mindsqualls</a>
<b>NXT Python</b>	Python	User Program running on PC	Standard	USB/BT	Desktop	Yes			Yes?	<a href="#">Python</a>
<b>My Robot Me</b>	Graphic?	User Program running on PC	Standard	USB/BT	Desktop	Yes	No	No	Yes	This web site seems to be gone... <a href="#">Robot Me</a>

## Notes

- (1) RobotC uses firmware that comes Standard with some LEGO software
- (2) LEGO's Mobile Application can send messages to a program running on an NXT

Other Team Hassenplug NXT stuff

## NXC programming:



LEGO® MINDSTORMS® NXT Blog  
Brick Command Center 3.3

## Example programs

## Program in Ebook

<http://www.juanantonio.info/lejos-ebook/>



## Sensors Design

# NXT Sensor Guide

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## Some sensors

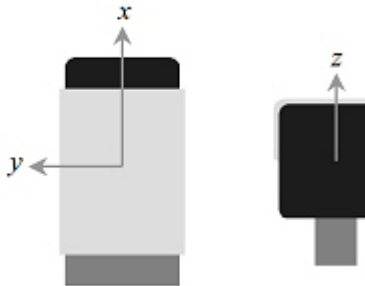
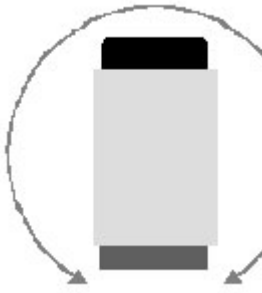
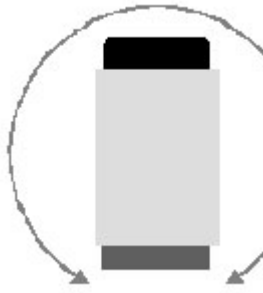
This is a list of some available sensors for the LEGO NXT

Sensor	Function	Possible Use	Where to buy?
Compass	read direction		HT/MS
Acceleration	read acceleration in three axis		HT/MS
Gyro	read rotation speed in one axis		HT
Color	Detect one of several preset colors, or return the color range for Red, Green & Blue		HT
RFID	RFID cards have a small radio in them that transmits a single, unique, and in this case, unchangable number. The sensor can detect those cards and return a value that represents that number.		
EOPD	More advanced Light Sensor		HT
Touch			LEGO
Ultra sonic	Detect range to object using sound		LEGO
Light			LEGO
Sound	detect sound level	none	LEGO
Rotation Sensor	detect movement distance & direction of motor		LEGO
Infrared Seeker	Find direction to IR ball		HT
Infrared Link	Connect NXT to RCX, Power Functions system, or IR Trains		HT
Sensor prototyping kits	Allow users to make their own sensors		HT

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## Acceleration Sensor, Gyro and Compass

One very common question about LEGO MINDSTORMS NXTs is: "What's the difference between a Gyro sensor, an Acceleration (or tilt) sensor, and a Compass sensor. This page will attempt to explain how each is different, and how they can be used.

Feature	Acceleration	Gyro	Compass
Function	read acceleration in three axis	read rotation speed in one axis	read direction
Data Axis			
Where to buy? Several companies sell sensors. This is one source.	<a href="#">Acceleration</a>	<a href="#">Gyro</a>	<a href="#">Compass</a>

Notes

(1) standard note

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## Common Questions:

Here are some answers to questions posted on [nxtasy forums](#) by our friend and **NXTpert** **Brian Davis** and also myself

**Q: If I'm correct, the acceleration sensor only measures when the sensor is, well, accelerating! Right?**

**A:** More exactly, it determines when the internal sensor is experiencing an acceleration relative to the outer casing.

**Q: Can I use an acceleration sensor to balance my robot?**

**A: No.** Actually, surprisingly, this doesn't work as well as you might like. The problem is when the robot is falling over, the acceleration sensor is not returning the angle the robot is at, but the acceleration it is under, which depends on the angle, as well as the angular velocity, as well as the angular acceleration. Building a LEGway style robot using both ground-sensing elements (and no, there is no "super-resolution" mode for the US sensor that I'm aware of) as well as a tilt sensor might allow hill climbing (something significantly more difficult), but I suspect the biggest limitation is going to be the speed of the software response. To get LEGway to balance well takes a "tight control loop" (i.e., very rapid and accurate correction).

**Q: Is a Gyro the same as a one axis acceleration sensor?**

**A:** Well... no. Not at all. The gyro sensor measures how fast it is rotating (or turning) in around one axis, *but that's it*. That's not an acceleration like the accelerometer measures. How to explain it...

Put yourself in an elevator with a compass sensor, a gyro sensor, and a 3-axis accelerometer. With the elevator at rest on the 13th floor, one axis of the accelerometer reads '200' (about 1 G), while the other two are very close to zero. the compass sensor reads something like '90' (it just happens, in this example, to be pointed just about due east), while the gyro reads '0' (it isn't turning).

Now spin the robot rapidly (but smoothly, not speeding up or slowing down) in place. The accelerometer will still read about '200' (down), as none of the linear accelerations on it have changed. But the compass sensor will start changing rapidly as the direction it points changes... '90' becomes '110' which becomes '130' etc, until at '359' it suddenly "drops" to '0' again and starts counting up. The gyro sensor on the other hand will show some constant value, like '15', as the unit rotates at 15 degrees per second. But it's not linearly accelerating.

OK, now cut the elevator cable. The accelerometer now reads '0' in all directions. Why? I mean, you are certainly accelerating (towards the bottom of the shaft in this rather touchy case). But the sensor within the accelerometer is now accelerating exactly the same as the casing to which it's attached, so it can't detect this, and reads zero. The compass still works, giving you which way you are facing relative to magnetic north. And the gyro still works, because it's measuring the rotation rate about one axis. Neither of these depend on an external acceleration.

I do suggest you step out of the plummeting elevator just before it hits the bottom

**Q: Can I use an acceleration sensor on a bot going a steady speed to tell whether or not I was flipped over or on a hill?**

Actually, yes. If the robot is moving at a steady speed, then there *is no acceleration* on it, and the only thing the accelerometer will report is the gravitational acceleration on the internal sensor itself. If that's all "down", then the robot is moving flat. If it's "half down and half forward" (i.e., two of the readings are about 140), then the robot is at a 45° angle, or if the reading is "about 200, in the opposite sense that it normally is", you know the robot is flipped over like a turtle on its back.

**Q: Will a pendulum always point down, as long as you let it be (not touch it or anything) and if the "counterweight" (the thing that is at the bottom of the pendulum) is heavy enough?**

**A: Well... no.** Although if it's any help, I have to re-teach this to college students as well.

In a *\*static\** situation, where things are not accelerating, then a pendulum at rest hangs straight down, and the mass it has makes absolutely no difference (in fact, the mass makes no difference to *\*gravitational\** accelerations of the pendulum, either - the result is the period of a pendulum is independent of the mass, something you can verify to yourself the next time you swing on a swing with your parent or child). But in the case in question there are certainly accelerations (other than gravity) to consider.

Think about it this way: I seal you in a little room on the top of a long pole that is hinged on the lower end, and you have a little plumb bob that is hanging straight down. Now, I let the pole tip to the side, toppling over. Does the plumb bob always remain pointed at the ground, or at the floor of the little room, or somewhere else? Well, I know that the instant before the little room hits the ground it is moving straight down, in "free fall", so at least at that moment, the plumb bob would not be "pointing" down - it would be floating, or drifting, in the little room.

When the pole had only tipped 45° for instance, my hand that is holding the plumb bob would be moving diagonally towards the ground - in fact, it would be *\*accelerating\** diagonally towards the ground, while the pendulum bob would be accelerating downward (due to gravity) as well as to the side (because of the string connecting the bob to my hand). The situation actually gets quite complicated.

This gets back to why an acceleration sensor is not the best way to balance a LEGway-style platform. After all, what is a pendulum but a different kind of acceleration sensor, but a very complex one to deal with.

**Q: What if the acceleration sensor was mounted very close to the ground?** (for a balancing robot) Wouldn't that negate some of the additional accelerations that you mentioned? I guess my theory is that if you mount the acceleration sensor at the pivot point of the "inverted pendulum", it should only tell you the angle it is currently at, right?

Of course the pivot point is where the tires are touching the ground, and you can't mount it there, but you could mount it very close, no?

**A:** Many of the above examples hold true when the sensor is placed near the "center of mass" of the robot. If the sensor is in a different location, many other (*confusing*) forces may come into play, making it even more complex.

**Q: What can you measure with an acceleration sensor:**

**A: Things Brian has done with an accelerometer...**

- Made a pedometer (counting footsteps)
- Logging accelerations while swinging (& jumping off)
- Playing on a merry-go-round
- Recording accelerations on rides at Disneyworld
- Measuring free-body rotations during free-fall
- Finding your way (or the robots way) up hills
- Having a robot that can flip itself back upright when it detects that it is upside down
- Using it for a no-moving-parts control stick for remote control robots
- Datalogging a hula-hoop
- Probably lots of other things I'm not remembering off-hand

The HiTechnic accelerometer is still one of my all-time favorite sensors, because it can do so much... but you have to understand how it works in order to take advantage of that. And the sad fact is (speaking as a physics teacher here) people, even intelligent, well-educated, "aged" people like myself, usually haven't spent enough time thinking about the differences between things like **position, location, velocity, speed, linear acceleration, angular acceleration, and angular position (or the difference between rotation and revolution**, or... dang, I think I need to go back to teaching again, the summer's been too long ).

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## Other Sensors (incomplete list)

Mindsensors Sensors

- Vision Subsystem (NXTCam)
- RCX Sensor multiplexer
- Multi-axis Acceleration Sensor
- RCX Motor Multiplexer
- RCX to NXT Communication Adapter
- Sony PlayStation 2 Controller interface

- Dual Infra Red Obstacle Detector
- Magnetic compass
- Pneumatic Pressure Sensor
- Realtime Clock
- High Precision Long Range Infrared distance sensor
- High Precision Medium Range Infrared distance sensor
- High Precision Short Range Infrared distance sensor
- Sensor building kit

## Others

- Lattebox servo controller
- Bluetooth GPS
- The many custom sensors people have created

<http://www.vernier.com/>

[http://findarticles.com/p/articles/mi\\_qa39...906/ai\\_n8874425](http://findarticles.com/p/articles/mi_qa39...906/ai_n8874425)

<http://www.techno-stuff.com/>

## "LEGO Certified sensors"

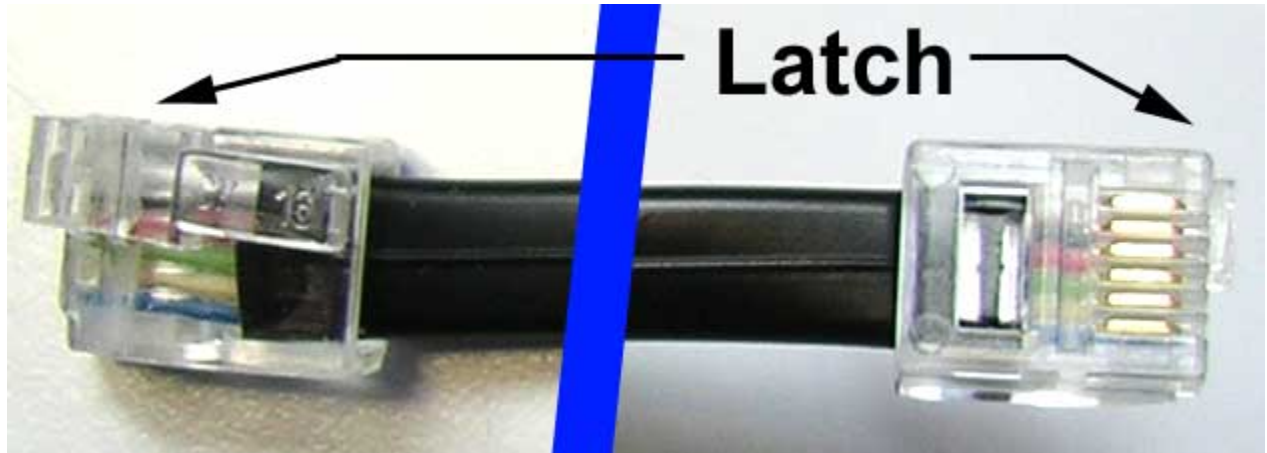
Some sensors are listed as "LEGO Certified". That means they pass LEGO's strict quality control standards. These include current limits and safety standards.

## Custom NXT<sup>®</sup> cables



Once you master [NXT plug synthesis](#), it's easy to create cables with custom length, as exemplified in the short cable above. You can also choose more flexible cables, round instead of flat cables...

Only one thing is really important: NXT cables are "straight" cables. That means that the same wire must be connected to matching contacts at both ends of the cable. With a flat cable, the connectors latches are thus placed on the same side, and on opposite face:



**December 2006 update:** several cables kits are available:

- LEGO [8529 kit](#) contains 7 cables, identical to those in 8527 NXT kit: [one 20cm \(8.5" \) cable, four 35cm \(14.5" \) cables and two 50cm \(18.5" \) cables.](#)
- HiTechnic [NWS1000 kit](#) contains 4 cables with different lengths: 12cm(4.75"), 16 cm (6.3"), 70cm (27.6") and 90cm(35.4"). These long cables can be handy!
- Mindsensors [Flexi-Cables](#) kit contains 4 cables with the same length as the LEGO ones: one 20cm (8.5" ) cable, two 35cm (14.5" ) cables and one 50cm (18.5" ) cables. Especially noteworthy - and useful! - is their flexibility, much greater than regular NXT cables.



A 50cm Flexi-Cable compared to a LEGO NXT cable.



Detail of Flexi-Cable end.

## Compatibility cables



A more interesting application of synthesized plugs is to build "compatibility cables" that allows you to use your old RCX sensors and motors with the NXT. LEGO sells these cables through its education channel (see [here](#)), but they are not yet available as of this writing.

**Warning:** as of this writing, programming software of the retail version of NXT kit (8527) doesn't support the use of some RCX sensors such as rotation sensor, light sensor or temperature sensor. The old touch sensor will work fine when used with NXT touch sensor block. RCX motors will work too with NXT motor block but of course all advance features that depends of the built-in rotation encoder can't be used.



We need one piece of NXT cable, obtained as explained [here](#), and one half 9V cable.

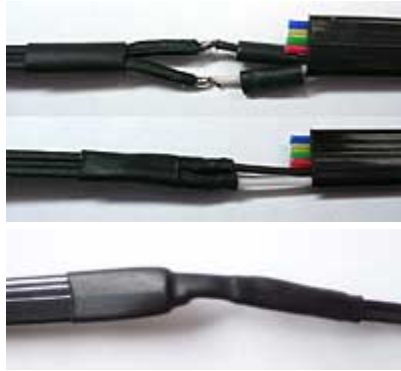


Only wires 1 and 2 of NXT cable are used for RCX stuff conversion. These wires are the ones on the NXT connector latch side. The other 4 wires are not used and are cut flush to the cable (**warning:** take care to make a clean cut to avoid short circuits between these unused wires).

All ends of wires are stripped and pieces of insulating heat-shrink tubing are prepared. The order of wires is not very important since the 2x2 9V



connector allows changing the orientation.



Wires are soldered together. Heat-shrink tubing is ...heat shrunk.

Heat-shrink tubing helps isolating wires and provides some strain relief.

### December 2006 update:



- As of this writing, programming software of the retail version of NXT kit (8527) doesn't directly support the use of some RCX sensors such as rotation sensor, light sensor or temperature sensor. You will have to download and install the [Dynamic Block Update and the Legacy Block Library](#).
- The [conversion cable \(8528\)](#) is available from LEGO.

### Additional NXT sensors by Mindsensors:

[http://www.mindsensors.com/index.php?module=pagemaster&PAGE\\_user\\_op=view\\_page&PAGE\\_id=57&qclid=CLCG1qOox5kCFRYiagod-ms-uw](http://www.mindsensors.com/index.php?module=pagemaster&PAGE_user_op=view_page&PAGE_id=57&qclid=CLCG1qOox5kCFRYiagod-ms-uw)

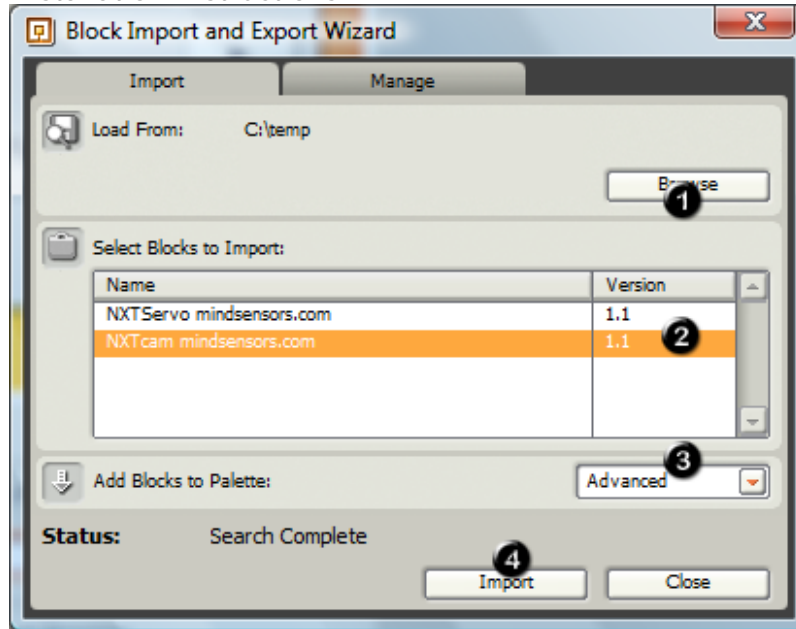
### NXTCam V2

[http://www.mindsensors.com/index.php?module=pagemaster&PAGE\\_user\\_op=view\\_page&PAGE\\_id=78](http://www.mindsensors.com/index.php?module=pagemaster&PAGE_user_op=view_page&PAGE_id=78)

### RCXmotor multiplexing

[http://www.mindsensors.com/index.php?module=pagemaster&PAGE\\_user\\_op=view\\_page&PAGE\\_id=58](http://www.mindsensors.com/index.php?module=pagemaster&PAGE_user_op=view_page&PAGE_id=58)

### Installation Instructions



- a. Download the block(s)
- b. Ensure that the downloaded file has .zip extension. If not, rename the file with .zip extension.
- c. Un-zip the files on your local machine (make a note of the directory).
- d. Open NXT-G 'Block Import and Export' wizard  
(If you are using NXT-G 1.0, you must have the Dynamic Block Update installed - from <http://mindstorms.lego.com/Support/Updates/>)
  1. Click on the Browse button and Select the directory you extracted the files to and Click OK.
  2. Select the block you need to install
  3. Select the Advanced Palette
  4. Click on Import Button
- e. Answer 'Yes' to any 'Replace ...' popup that might show up

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#### These Blocks are Open Source.

Protected under GNU Public License as published by Free Software Foundation; version 3 of the License. You are welcome to modify and enhance these blocks and learn from them. If you do modify, please e-mail us the updates, and we will post them to this location.

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## NXT Robot Projects with Vernier Sensors

Here are several videos of the LEGO® MINDSTORMS® NXT projects we have done. We created the Vernier Sensor Block for the MINDSTORMS NXT software for use with our sensors and the Vernier NXT Sensor Adapter.

Choose a project for a full description, view demo movie, and download available source code from [our engineering site](#).



### [Acidity Tester](#)

We built a robot to sort a set of beakers into "acidic" and "safe" liquids.



### [Air Compressor](#)

We built a pneumatic pump and switch.



### [Aquarium](#)

We built a device to test three properties of water in an aquarium: conductivity, pH, and dissolved oxygen.



### [Balancer](#)

We built a device to automatically balance a horizontal beam as weights are added to either end.



### [Battery Tester](#)

We built a device to test the current flow through a battery as it lights up a lamp.



### [Blind Student Assistant](#)

We used LEGO® MINDSTORMS® NXT to create two programs that could be very useful to a blind student in a science course. The program speaks Vernier sensor readings or makes a tone with a frequency proportional to the sensor reading.



### [Compass](#)

We built a robot to detect the earth's magnetic field and head true north or south.



### [LEGO Chemistry](#)

We built a device to add a dry chemical to a liquid, shake the solution, and then measure the temperature.



### [Leveler](#)

We built a robot to carry a cup of water up and down hills without spilling it.



### [Magnet Finder](#)

We built a robot to detect a magnet hidden under one of three walnut shells.



### [NXT Golf](#)

We wanted to show the science behind the popular computer games which use wireless sensors to sense motion. We used a Vernier Low-g Accelerometer and a LEGO® MINDSTORMS® NXT connected over Bluetooth to a computer running LabVIEW.



### [NXT Ice Skater](#)

Our ice skater simulates the change in rotational speed when ice skaters extend or tuck in their arms.



### [Pit Viper](#)

We made a snake robot that uses two surface temperature sensors to detect its prey.



### [Plant Waterer](#)

We built a device to automatically water houseplants when the soil becomes too dry.



### [Remote Data Collection Over Bluetooth](#)

We've developed a LabVIEW VI that is designed to receive and save four channels of data from your NXT unit via a Bluetooth link.



### [Salinity Adjuster](#)

We built a device to increase the salt content of a solution.



### [Tea Maker](#)

We decided to build a robot that simplifies the tea brewing process. It does everything short of boiling the water.



[UV](#)

We built a robot to study the UV absorption of various sunscreens.

### Other NXT Robot Project Ideas

We also have many concepts for robotics projects using our sensors. Feel free to use any of them as a starting point for your explorations.

- [Low-g Accelerometer](#)  
Use the accelerometer as a tilt sensor ([example 1](#), [example 2](#)), or use it to study acceleration of a robot itself.
- [Magnetic Field Sensor](#)  
Build a robot that migrates toward magnetic north ([example](#)), or a robot that finds a hidden magnet ([example](#)).
- [Surface Temperature Sensor](#)  
Have a robot explore a room and look for warm and cool spots. Have a robot detect a warm object by its heat, as some snakes can do ([example](#)).
- [Dual-Range Force Sensor](#)  
Measure the force or torque that a robot can produce, measure mechanical advantage of gear and pulley systems, measure friction force as a robot pulls an object.
- [Gas Pressure Sensor](#)  
Build an air compressor ([example](#)).
- [pH Sensor](#)  
Make a robot which sticks the probe in a glass and yells if it finds an acid ([example](#)), or test aquarium conditions, ([example](#)).
- [Stainless Steel Temperature Probe](#)  
Monitor the temperature of solutions; make a robot to make a cup of tea and monitor the temperature until it is ready for drinking and then sound an alarm; make an automated system to do temperature measurements ([example](#)).
- [Soil Moisture Sensor](#)  
Make an automatic plant watering system ([example](#)).
- [UVB Sensor](#)  
Study the effectiveness of sunscreens ([example](#)).
- [Differential Voltage Probe](#)

Measure voltage supplied by the NXT batteries, study how batteries hold up under different conditions, study electrochemical cells.

- Current Probe  
Study the current used by the NXT as it runs the motors in various conditions, or test batteries, ([example](#)), or test the output of solar cells as they are raised and lowered by the NXT.
- Hand Dynamometer  
Study grip strength of students. One person has made a robot that makes a higher and higher tone as you squeeze harder and if you reach a certain limit, it says ouch!
- Conductivity Probe  
Study concentration of salt solutions or build an automated system to maintain a specific level of conductivity ([example](#)). This movie was done with a salinity probe, but the idea is the same.
- Dissolved Oxygen Sensor  
Measure the level of dissolved oxygen in a container of water before and after the robot shakes the container; monitor the status of an aquarium.
- Barometer  
Study air pressure for weather studies, or study small pressure changes cause by the Bernoulli effect.
- Extra Long Temperature Probe  
Make a robot that lowers the probe into a lake slowly to monitor temperature profile of the lake.
- Instrumentation Amplifier  
Measure small voltages (mV).
- 25-g Accelerometer  
Measuring acceleration in collisions between robots, or parts of robots.
- Relative Humidity Sensor  
Use as part of a weather station.
- Light Sensor  
Use to study lighting levels. Even though the NXT comes with a light sensor, this one is very different in two ways. It has a spectral response that approximates the human eye (vs the NXT light sensor, which is more sensitive to infrared light. This sensor has a switch to allow you to select one of three ranges, from the brightest sunlight to dim lighting.)
- O<sub>2</sub> Gas Sensor  
Studying the exhaled breath of a human, or maybe monitoring O<sub>2</sub> use in a chemical reaction.
- Salinity Sensor  
Test ocean and estuary samples or build an automated system to maintain a specific level of conductivity ([example](#)).

- [Sound Level Meter](#)  
Build a robot that decides which group of students is loudest and heads toward them.
- [Colorimeter](#)  
Use to do Beer's law experiments on the concentration of a solution.
- [Charge Sensor](#)  
Make a robot to move a charged object near the charge sensor and study how the charge measured varies with distance.
- [ORP Sensor](#)  
Measure oxidation reduction potential, for example in a swimming pool.
- [Force Plate](#)  
Measure force when students jump.
- [Flow Rate Sensor](#)  
Measure the flow rate of a stream.
- [Electrode Amplifier](#)  
Use with a pH probe that you already own. It has a standard BNC connector.
- [Thermocouple](#)  
Measure flame or oven temperatures.
- [Turbidity Sensor](#)  
Measure the clarity of water.
- [UVA Sensor](#)  
Measure UV produced by lamps.
- [Infrared Temperature Sensor](#)  
We normally do not list the infrared temperature sensor as compatible with the NXT, since it will not work at temperatures below about 22°C, but can be used as long as you work with objects warmer than normal room temperature. For example, you could make a robot that rotates the sensor around and finds the warmest object.

## Download Vernier Sensor Block for use with MINDSTORMS NXT software

To use the Vernier NXT Adapter with LEGO® MINDSTORMS® NXT software, you need the Vernier Sensor block. This is a free download.

Instructions for importing the block into your MINDSTORMS NXT software and using it for programming are included in the download.

## For MINDSTORMS NXT 2.0 Software **NEW**

- [Download Vernier Sensor Block - version 2.0](#) (1 MB ZIP)
- [View Vernier Sensor Block 2.0 instructions](#) (195 KB PDF)
- *Last updated: December 23, 2008*



## For MINDSTORMS NXT 1.1 Software

- [Download Vernier Sensor Block - version 1.02](#) (1 MB ZIP)
- [View Vernier Sensor Block 1.02 instructions](#) (237 KB PDF)
- *Last updated: March 18, 2008*

## Information on the NXT cables

<http://www.techbricks.nl/My-NXT-projects/nxt-cable-connector-tongs.html> (make your own RJ12 cable)

<http://www.philohome.com/nxtcables/nxtcable.htm>