LEGO for the 1990's

The Lego Dacta Control Lab

As we grow older and more mature, it's nice to see that things we remember from our childhood have matured along with us.

Most of us have grown up a lot quicker than we ever thought we would. It's unfortunate, too, that once we leave adolescence, we seem to lose touch with the toys we played with as kids.

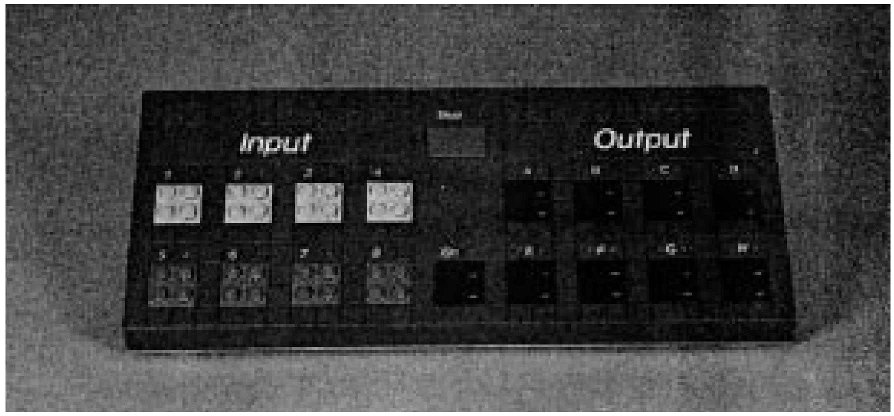
As an example, we'd be willing to bet that almost every reader of this magazine has played with a Lego set at one time or another. Lego building blocks are instantly recognizable worldwide. Even adults like to play with Lego (when they're lucky enough to have the time).

Most of the Lego sets we remember contained lots of fairly plain blocks that left much to the imagination, but they were still fun to play with. Some of the more deluxe Lego sets included specialized parts that adeed new dimensions of motion and a more finished appearance to projects. However, none of us would have ever imagined the capabilities of today's Lego.

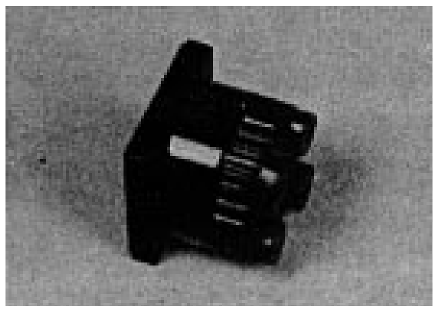
Today's Lego. Lego has always been an excellent tool for helping children develop manual dexterity and mechanical concepts. Now, Lego is also an excellent way to learn how to use computers and software to control mechanical devices.

The Control Lab Starter Pack from Lego Dacta, the Education Division of the Lego Group (555 Taylor Road, Enfield, CT 06083-1600; Tel. 800-527-8339), contains everything you need to build a greenhouse project, a dynamometer, a pick-and-place robot arm, a color-code reader, motorized bridges, and much more. The only thing that's not included in the Control Lab is a PC or Macintosh computer to control the projects.

The heart of the Control Lab is the interface unit that connects to the serial port of a computer. Software loaded on the host computer communicates with that interface, to which various electronic parts are connected. Half of the interface's front panel contains ports for connecting input devices such as sensors for temperature, touch, angle, and light.



The heart of the Control Lab is the interface unit, which connects to the serial port of a computer. The left half of the interface's front panel contains ports for connecting input devices (sensors) and the right half is for output devices (motors, lamps, etc.)



This tiny sound element makes a beeping noise when current flows in one direction and a warbling sound when the current is reversed. It will also change sounds if you twist its top 180•.

The eight input ports are labeled 1-8. The other half of the front panel has ports for output devices such as motors, lamps, and sound elements. The output ports are labeled A-H.

We worked with the No. 943 Control Lab Starter Pack intended for use with a PC. There's also a No. 942 Control Lab Starter Pack for use with a Macintosh. The PC requirements are DOS 3.1 or greater, 640K RAM (although 1 megabyte is recommended), a mouse, a hard disk, an EGA or better monitor, and one available serial port. The Mac requirements are System 6.0 or higher, 1 megabyte of RAM, Finder 6.0 or higher, a hard disk, and a free serial port.

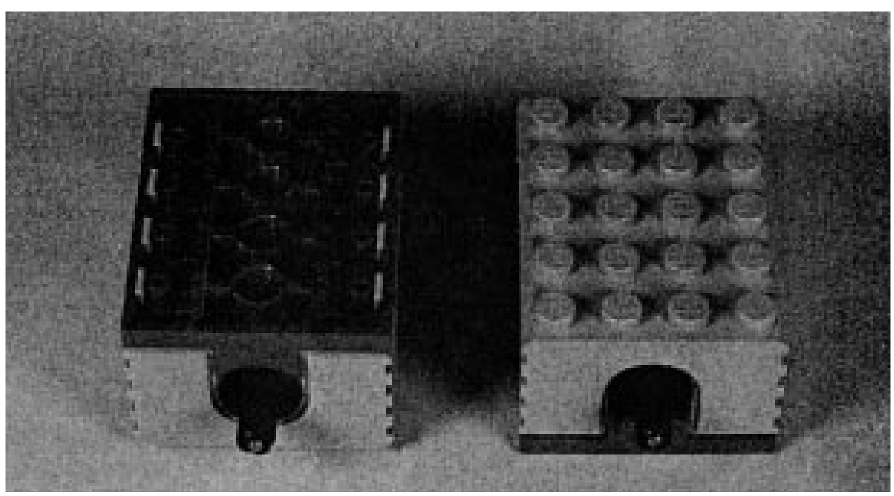
Both the No. 942 and No. 943 Control Labs carry an individual license and a price tag of $599. Two other packages include the same materials for Mac's and PC's, but with a site license, for $750. While the pricing might seem steep at first, keep in mind that the labs are intended for a classroom environment, to be paid for by a school rather than an individual. However, should an individual want to purchase a Control Lab for his own use, we're sure that the price tag will seem reasonable once the lab's capabilities are realized.

Lots of Parts. In addition to enough documentation for an entire classroom, the Control Lab contains 527 pieces including 3 motors, 4 lamps, 1 sound element, 1 touch sensor, 1 temperature sensor, 1 light sensor, 2 angle sensors, and plenty of power connectors of different lengths. Two bases are included, so depending on what projects are chosen, it is possible to have a classroom working on two different projects at once. However, only one serial interface is included with the Control Lab, so only one project can be controlled at a time.

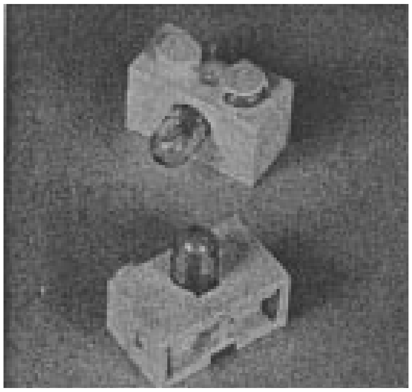
As interesting as the projects built from the Control Lab are, what's perhaps more interesting is how clever some of the individual Lego components are, and how they're powered. Power is applied to motors and lamps via jumper wires with 2 x 2 Lego blocks at each end. Each block has specially shaped electrical contacts on each bump on top and in each hole on bottom. Those blocks allow DC power to be connected to a part in any position, and it is impossible to short anything out. You just press one of the connectors onto an accessory in almost any position, top or bottom, and power is supplied to it almost as if by magic. You'll have to play with them yourself to see what we mean.

Sights and Sounds. One of the most interesting parts in the set is a tiny sound element about the size of a 2 x 2 Lego blocks. It has a square base for its electrical connections, and a swiveling round top. The serial interface has one test connector on it that can be used to power a motor, lamp, or sound element with no help from the computer. With the interface unit powered up, and the sound element pressed onto the test connector, the element will beep repeatedly. If you remove the sound element, turn it 180°, and push it back on, it will make a warbling sound.

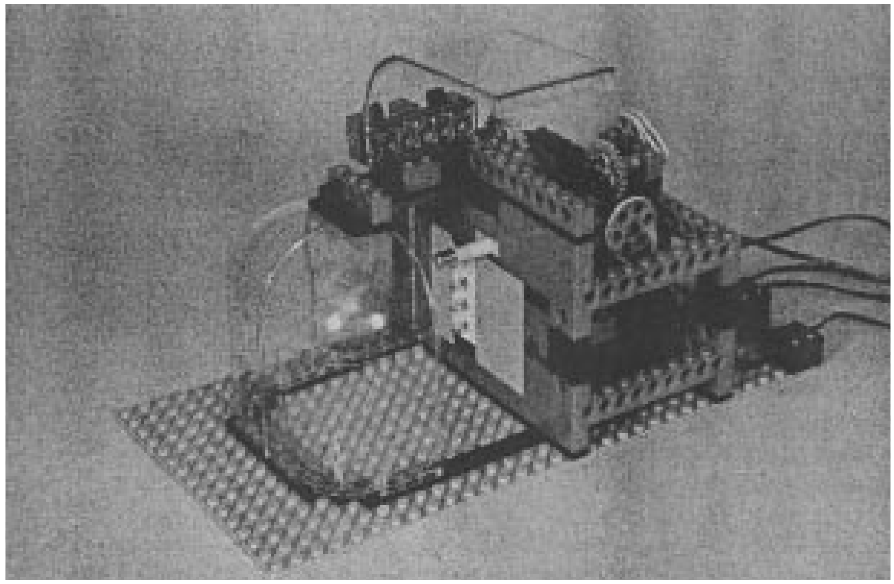
Similarly, if you leave the sound element in the same position, and simply twist its circular top 180 degrees, its sound output changes. With two different sound outputs, and the ability to



The motors have a small drive shaft sticking out of one end onto which wheels, gears, belts, propellers, pulleys, or axles can be attached.



Incandescent lamps have colored lenses that can be placed over them to make different colored indicator lights. Also included are reflectors that make the light more focused.

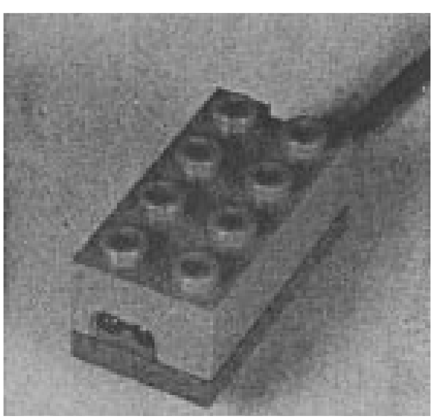


This greenhouse has a motorized "glass" door that opens and closes, an angle sensor to detect the position of the door, and an inside temperature sensor. The door can be opened and closed manually or automatically according to the inside temperature conditions. The sound element beeps when the door is opening and warbles when it's closing. We added lights and a light sensor.

switch between them either by reversing current direction (which the serial interface can do under software control) or by mechanical action, the possibilities for using the sound element are almost endless.

For light, four small incandescent lamps are fitted into small 1 x 2 blocks, and power can be applied to those blocks from the top or bottom. Various colored "lenses" can be placed over the lamps to make them into different-colored indicator lights. Also included are reflectors that fit over the lamps to focus their light.

Motion and Feedback. The three motors included in the set are all the size of a 4 x 5 block with a small drive shaft sticking out of one end. Various wheels, gears, belts, propellers, pulleys, and axles can be attached to any drive shaft. Power is supplied to the motors from the bottom surface, and the direction a motor rotates depends on the current's polarity. Therefore, motion can be reversed under computer control. Because the motors have Lego bumps and holes, top and bottom, they can be used as structural components in mechanical assemblies, as can most of the parts in the kit.



The light sensor can provide a relative indication of the ambient lighting and a reading of the light reflected off a surface placed near the sensor.

Among the various sensors included in the Control Lab, one is for measuring temperature. That 2 x 3 Lego block has a temperature probe sticking out of one end and a permanent lead on the other. When the temperature sensor is connected to the serial interface, and the software is up and running, an actual temperature reading can be displayed on a computer monitor in either Fahrenheit or Celsius.

The touch sensor is really just a push-button switch housed in a 2 x 4 Lego block with a permanent lead attached. The edges of the button are tapered to enable cam-action switching. Also, an axle can be pushed into a hole at the end of the button to extend the switch's reach. Under software control, the state of the switch can be displayed on-screen.

An unusual light sensor is housed in a 2 x 4 Lego block. One end of the sensor has both a light emitter and light receiver built into it and the other end has a permanent lead attached. Not only can the sensor provide a relative indication of the ambient lighting on-screen, it will also give a reading of the light reflected off a surface placed near the sensor. That allows for projects such as color-code readers. Add an automated conveyor belt and a robot arm, and you could build an automated sorting system! But we're getting ahead of ourselves.

The angle sensors, also housed in 2 x 4 blocks, contain a rotating section through which you can slide an axle. You and the software can then keep track of the number of shaft rotations as well as the shaft position on any kind of device you build.

Software Setup. The software included with the Control Lab is written specifically for its intended platform (whether PC or Mac). Even so, the PC version that we used has a definite Mac look to it, indicating that the system was originally designed for a Mac and ported over to the PC. However, by no means is the software difficult to use on a PC, and we had no problems with it.

The main screen resembles the front

panel of the serial interface. Icons are grouped on both sides of the display for input and output devices. To set up the software, you drag device icons to their particular position on the serial-interface illustration using the mouse. The on-screen port then labels itself as "motora," "lampb," or whatever.

For motors and the sound element, two on-screen buttons above each port control the direction or the sound of its associated device. The on-screen buttons are positioned in the same places as indicator lights on the serial interface. You just click the mouse on a button to activate a device. While a button is being clicked, the corresponding light on the interface illuminates.

Similarly, icons for input devices are dragged onto input ports and the ports label themselves accordingly. When an angle sensor is first set up, it displays an angle of 0. Then, depending on the number of turns and the direction, a positive or negative number is displayed. Angle-sensor readings can also be reset to zero without rotating the shaft if desired. The output from a light sensor is also a number, although always positive.

The temperature sensor's readout is an actual temperature reading in Celsius by default. It's easy enough, though, to change the readout to Fahrenheit. The touch sensor's readout is simply the word "true" or "false," depending on whether its button is pushed in or not.

Software Use. Finished projects can be controlled manually from the main "project" screen, which can be saved as a file for later use. Also, control panels can be set up to allow easy control and monitoring of projects using mouse-operated buttons and slider switches. For example, the speed and direction of a fan could be controlled from a slider switch and button.

Control panels can be customized in many different ways. A graph tool lets you add a graph box that can display sensor results such as temperature over time. Text and pictures–a lamp, a motor, etc.–can also be added to control panels.

Programs can be written for automated control of projects. Programming is done in a sort of "Lego BASIC," which is very easy to understand and use. It also has built-in on-line feedback to help pinpoint and correct syntax errors. Take, for example, the following simple program for a project entitled "thermostat." The project contains a temperature sensor that's heated up by a lamp and cooled by a fan:

```
TO THERMOSTAT
FOREVER [IF TEMP4 > 75 [TALKTO "MOTORA SETPOWER 8 ON]
FOREVER [IF TEMP4 < 73 [TALKTO "MOTORA OFF]
END
```

The programming language is so simple that you can probably figure out what each instruction does by yourself, but we'll explain it anyway. The first line simply activates the thermostat project. The second line tells motora (the fan motor) to turn on and stay on at power level 8 if the temperature is above 75 degrees. The third line tells the fan to turn off when the temperature drops below 73 degrees. Simple enough? If four simple program lines can do all that, imagine what a longer program can do!

Documentation. Four main instruction books are included with the Control Lab. The first one (which has 50 pages) is the *Setup Guide and Introductory Explorations*. The purpose of the book is to introduce the user–or more likely the teacher–to all the components in the lab. All of the specialized input and output devices are explained and experimented with individually. Then software commands are discussed and tested. Quite a bit about the lab is explained by that one manual.

The second manual, again about 50 pages, quickly goes over building a simple fan-control project. To prove that the emphasis of the Lab is on software control rather than building things, the fan itself is fully asembled by the end of page 7; pages 8-53 are devoted to controlling the fan, both manually and automatically.

A thick reference guide covers all aspects of the software and programming in great detail. There's enough information in that book to develop incredibly intricate programming for any conceivable type of device. The last book is seentially a classroom guide to several complete projects, or just an owner's manual if an individual is fortunate enough to acquire a Control Lab for himself.

Complete assembly plans are given for 7 projects: a greenhouse, a color-code reader, a dynamometer and motorized car, a joystick-operated wheelchair, a scanner, a sorter, and a robot arm. The projects are truly fascinating because of their functional complexity and physical simplicity–while they all do totally different jobs, they all use the same handful of input and output devices.

Dream On. The Control Lab is somewhat unbelievable in all that it can do–it can do almost anything. Lego has certainly grown up since we were kids, and we're betting that in ten years or so we'll see a Lego Dacta Space Shuttle kit on the market–okay, maybe 15 years.

For now, though, we built the greenhouse project. The plans called for a motorized "glass" door that opens and closes, an angle sensor to detect the position of the door, and an inside temperature sensor. The door can be opened and closed manually or automatically, according to the inside termperature conditions. The sound element beeps when the door is opening and warbles when it's closing. We added lights and a light sensor to the inside of the greenhouse just for fun. If that kind of creativity sounds like fun to you, you're sure to enjoy building the many things possible with the Lego Dacta Control Lab.