

# Cartesian Diver



*Figure 1: One example of a Cartesian diver using a LEGO Pneumatic Hand Pump*

A Cartesian diver is a classic science experiment, named for René Descartes, which demonstrates the principle of buoyancy. The “diver” is a small, rigid tube (such as an eye dropper), open at the bottom end and sealed at the top. When immersed in an airtight, but flexible container of water, the diver will float near the water surface. When the container is squeezed (light pressure applied by hand), the diver will sink to the bottom of the container. Increasing the container’s pressure by squeezing affects the least dense material in the container, which is the air inside the diver. This occurs because of Pascal’s Principle, which states that pressure on a fluid is transmitted unchanged throughout the fluid. In this project, your challenge is to build a sensor-controlled robotic device to replicate a Cartesian diver.

## DESIGN REQUIREMENTS

In this project, you will design and build a stationary air-pumping station for a Cartesian diver apparatus. Your device should replicate the pressurization caused by squeezing a handheld bottle. You will use a LEGO Pneumatic Hand Pump and Vernier Gas Pressure Sensor to automatically pressurize the bottle causing the diver to sink to the bottom. (**Note:** You will not be building a robotic device to actually squeeze the bottle.) Once your diver has reached the bottom of the bottle, you should use a LEGO Pneumatic Switch to ease the pressure on the bottle allowing the diver to rise to the surface. Your pressurization and release cycle should be determined by feedback from the Gas Pressure Sensor.

## ***Project 10***

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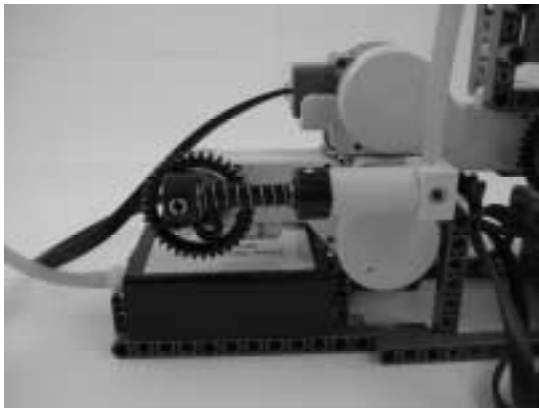
You are strongly encouraged to use the Engineering Design Method and your creative imagination when tackling this challenge. The Engineering Design Method will help you develop a successful working robot. A little planning will save you time and frustration, especially when working on more complicated projects. To help you get started, use the *Engineering Design* worksheet provided by your teacher.

### **MATERIALS**

Computer	two-hole stopper assembly
LEGO MINDSTORMS NXT Educational Set	plastic water bottle
MINDSTORMS Edu NXT 2 software	pneumatic tubing
Vernier NXT Sensor Adapter	Luer-Lock connector
Vernier Gas Pressure Sensor	dropper
LEGO Pneumatic Hand Pump	safety goggles
LEGO Pneumatic Switch	<i>Engineering Design</i> worksheet

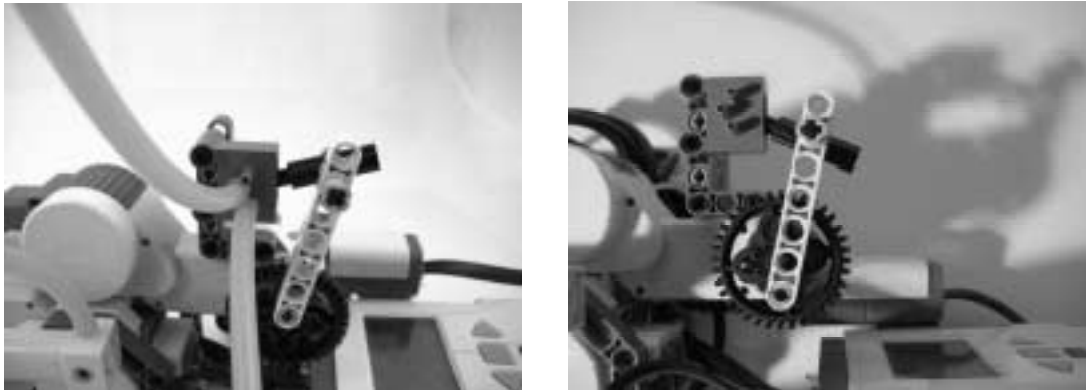
### **TIPS**

- You should do some initial testing to determine the pressure values when your diver is floating (you are not squeezing the bottle) and sinking (you are squeezing the bottle) to help you set the pressure limits for your pumping cycle.
- The LEGO Pneumatic Pump can be connected to an NXT motor as shown in the photos below.



*Figure 2. The LEGO Pneumatic Hand Pump connected to an NXT motor*

- The LEGO Pneumatic Switch can be attached to an NXT motor so that it is controlled as shown in the photos below.



*Figure 3. The LEGO Pneumatic Switch controlled by an NXT motor*

In the photo on the left, the lever on the switch is up creating a connection between the middle and lower ports on the switch. If you connect the water bottle to the middle port and the Pneumatic Hand Pump to the lower port, the pressure in the bottle will increase when the motor is driving the pump.

In the photo on the right, the lever is down creating a connection between the middle and upper ports on the switch. Nothing should be attached to the upper port, allowing air to escape and the bottle to lose pressure when the switch is in this position. Note how the LEGO Pneumatic Switch is connected to the motor.

# Vernier Lab Safety Instructions Disclaimer

**THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.**

**This copy does not include:**

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *STEM 2 with Vernier and LEGO® MINDSTORMS® NXT* lab manual includes 12 lab activities and eight projects as well as essential teacher information. The full lab book is available for purchase at: <http://www.vernier.com/cmat/stem2.html>



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