

MIT Sea Grant

Autonomous Underwater Vehicles Laboratory

Sensor v2.4.1 Feb 2010 Instruction Manual

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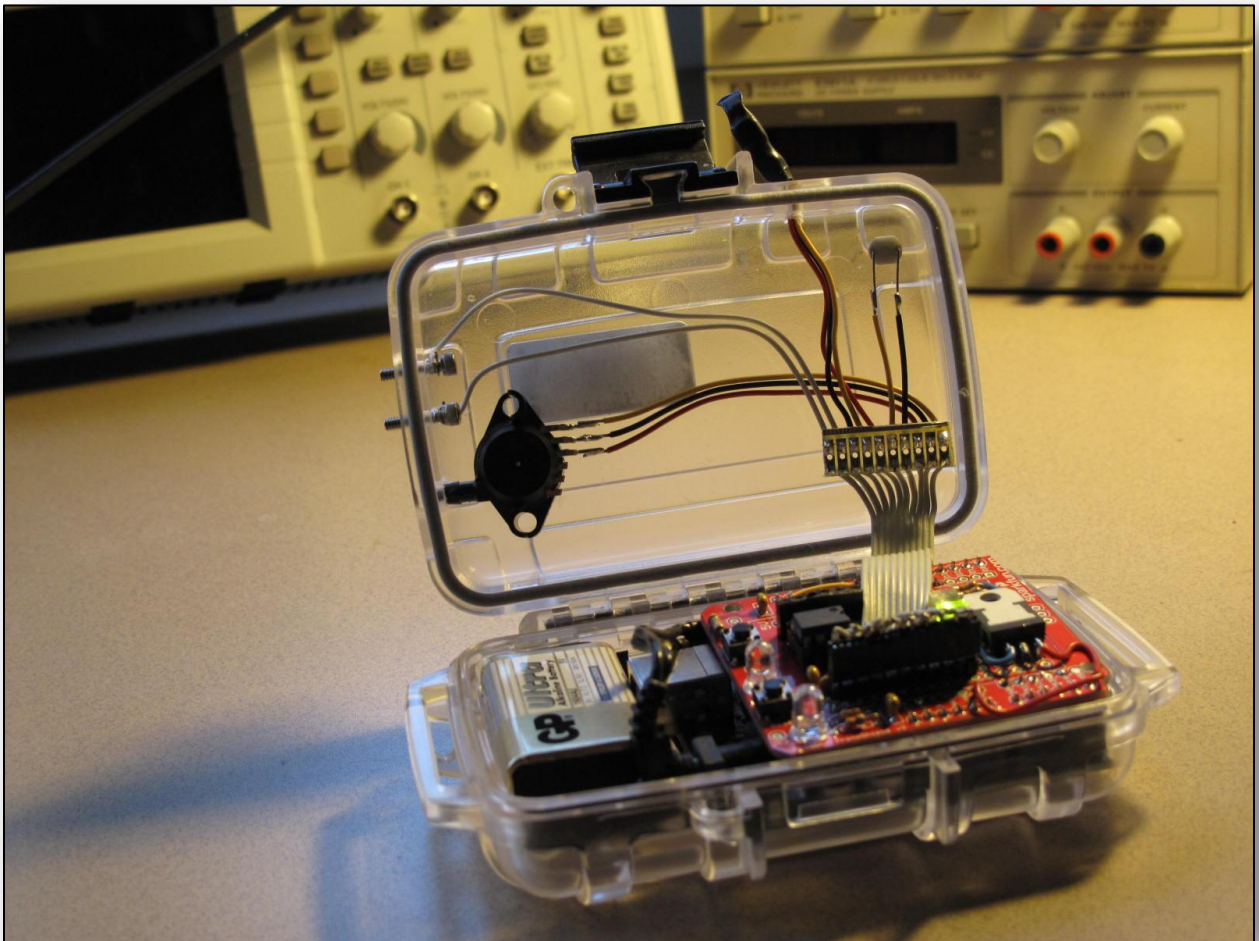


Table of Contents

| | |
|---|-----------|
| Safety Notice | 3 |
| Introduction | 4 |
| Section 1 – Circuit Board Assembly | 5 |
| <i>Installation of Board Basics</i> | 6 |
| <i>Installation of the Pressure Sensor</i> | 6 |
| <i>Installation of the Temperature Sensor</i> | 6 |
| <i>Installation of the Light Sensor</i> | 7 |
| <i>Installation of the Conductivity Sensor</i> | 7 |
| <i>Installation of the Data Storage Hardware</i> | 7 |
| <i>Connecting the Sensors</i> | 8 |
| <i>Installation of Power Switch</i> | 8 |
| Section 2 – Housing Assembly | 9 |
| <i>Fabricate the Housing</i> | 10 |
| Section 3 – Installing the Software | 11 |
| <i>Setting up your MicroSD Card</i> | 11 |
| <i>Installing the Programming Environment and Libraries</i> | 12 |
| <i>Installing the Software on the Arduino</i> | 12 |
| Section 4 – Testing the Sensors | 13 |
| Section 5 – Calibration | 14 |
| <i>Conductivity Sensor Calibration</i> | 14 |
| Parts | 15 |
| Template | 17 |

Safety Notice:

Please ensure that you read and understand all of the safety rules that comes with your tools. If used properly, they will provide you with a fun, successful experience creating this sensor. If used improperly, many of the tools can cut or burn, providing a health risk, and ruining the fabrication experience.

Included at the end of this manual are documents pertaining to all of the parts included in this kit. Please look through these for the manufacturers recommended safe handling instructions. Some parts are small and present a choking hazard; others are sharp and have the ability to penetrate skin. Some components require safe handling to prevent accidental shock to the component, or safe heating to prevent the melting of parts.

Be safe, Have fun.

MIT Sea Grant

Introduction

The MIT Sea Perch Sensor Suite is an electronics project designed to educate the fabricator in the electronics and mechanics of ocean sensing technology. Through building this project, knowledge will be gained in basic and intermediate electronics, microcontroller programming, and waterproof design. It is possible to exclusively build this project without taking the time to learn the fundamental principles at work; and doing so will result in a working sensor. However if the time is taken, a world of sensors, autonomy, and ocean understanding can be unlocked.

The final product that will be assembled by following these instructions is a simple water quality sensor. It is capable of sensing depth, conductivity, temperature, and light, and storing the data for hours at a time on a MicroSD card.

Some modifications have been made to circuit 2.4, creating circuit 2.4.1. Essentially, the circuit is the same allowing for the same manual to be used for both models. You may note slight variations in imagery in this document when compared to your circuit. Where it is important, a note will exist indicating the difference and how it applies to your board.

Section 1 – Circuit Board Assembly

Please read all steps carefully. The text will be kept to a minimum, but it is essential to make note of it where it exists.

- After verifying that all parts are included and the safety notices have been read, begin by creating a clean workspace. There are many small parts that will easily be lost.
- The majority of the steps for this section are presented in photo format. Compare your circuit board to the photo, and add the components shown to make your circuit look like the one shown.
- When soldering, there is no correct or incorrect side to do so on. If you have access to the terminal on the board with the soldering iron, that is an acceptable place to solder. There is no need to solder both sides, but it is okay if you do. Note that although solder can be applied to either side, the components are side specific.

Note – This is a modified instruction manual in beta testing. Some of these steps are included exclusively to accommodate imperfections included with this beta version. *Check that your circuit board serial number is identical to the number indicated on the front page.* If not, obtain a different manual.

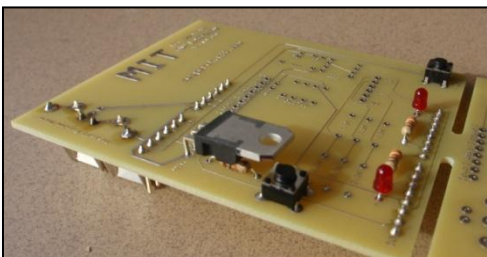
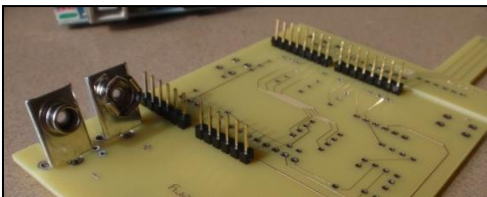
Assembly of the Circuit Board

Installation of the Board Basics

- You will need the Following components:
 - 2 x 330 Ohm Resistors (o o br)
 - 1 x 10K Ohm Resistor (br bl o)
 - 2 x Red LEDs
 - 2 x Buttons
 - 32 Pin Male Header
 - 7805 IC Voltage Regulator
 - + 9 Volt Battery Terminal
 - - 9 Volt Battery Terminal
- Cut the 32 Pin Male Header into two eight pin segments and two six pin segments. Put the rest aside.



- Install the components as shown. The short lead of the LED is to be installed in the hole marked "-". Note the side of the board the components are installed on. **The LEDs and resistors are mounted in a different location on board 2.4.1**



Installation of the Pressure Sensor

- You will need the following components:
 - MPX4250GP Pressure Sensor
 - 6" of 1/8" ID tubing
- For this installation, we will refer to the pin with a small notch cut in the side as Pin 1, the flat surface of the sensor as the back, and the opposite side as the front.
- The photo shows a sensor with three pins removed. **Do not do this.**
- Bend the pins to the back of the sensor so they are all in a line at 90 degrees to their original position. Pin 1 should be installed in the square hole.



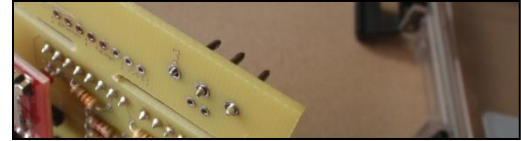
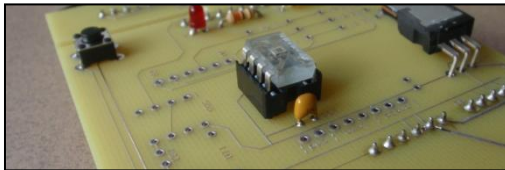
Installation of the Temperature Sensor

- You will need the following components:
 - 3 Pin SIP Machine Socket



Installation of the Light Sensor

- You will need the following components:
 - 8 Pin DIP Socket
 - 0.1uF (104) Capacitor
 - TAOS TSL230R Light Sensor
- Orientation matters here. Pin 1 of the Light sensor is indicated by a faint indented circle on the front face of the chip in the left corner. Pin 1 on the DIP socket is the pin to the left of the notch.
- Solder the DIP socket, but not the Sensor. This installs with nothing more than a press fit. If the legs of the sensor are splayed too far apart, use a table or other flat surface to apply even pressure and correct the misalignment.

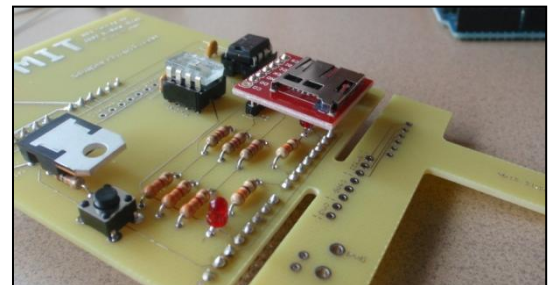
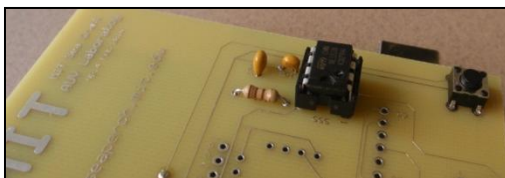


Installation of the Data Storage Hardware

- You will need the following components:
 - 3 x 3.3K Ohm Resistors (o o r)
 - 3 x 1.2K Ohm Resistors (Br r r)
 - The Remainder of the 32 Pin Male Headers
 - Micro SD Breakout Board
- **The terminal labeled "CD" is not used on the Micro SD Breakout Board.**
- Cut a six pin segment off of the Male Header, put the remainder aside.
- This six pin segment will connect between the Micro SD board and the main board.
- Circuit Board V2.4 requires that the Micro SD board be installed over one of the LEDs.

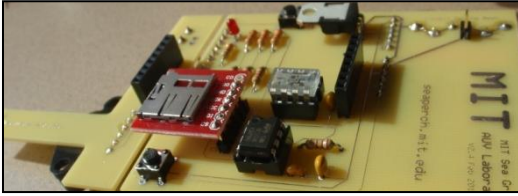
Installation of the Conductivity Sensor

- You will need the following components:
 - 8 Pin DIP IC Socket
 - 0.1uF (104) Capacitor
 - 0.01uF (103) Capacitor
 - 555 Timer IC
 - 110 Ohm Resistor (Br Br Br)
 - 3 Pin Male Header
- Both the DIP and the 555 IC indicate the location of pin 1 to the left of the notch. The 555 IC has a small indented circle over pin one on the left side of the chip.

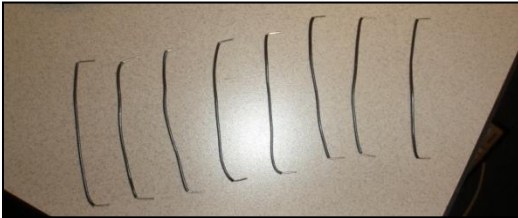


Connecting the Sensors

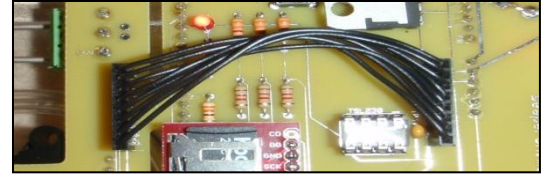
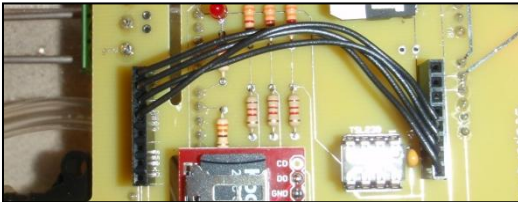
- You will need the following components:
 - 2 x 8 Pin Female Headers
 - 15" of 22 Gage Solid Core Wire



- Cut the 15" piece of wire into 8 segments, then strip off approximately 3/8" from each end and bend the stripped part at 90 degrees as shown below.

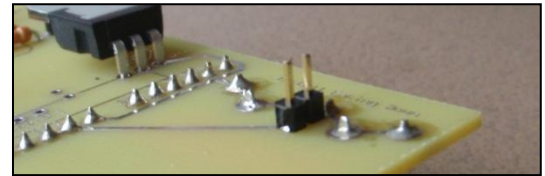
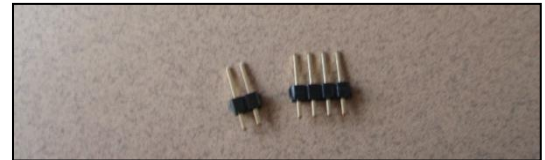


- The wires need to cross, i.e. Pin 1 connects to Pin 8, Pin 2 to Pin 7 and so on.



Installation of the Power Switch

- You will need the following components:
 - Remaining Male Headers
 - Jumper
- Cut 2 pins from the Header



- *For Circuit 2.4.1, the pins and jumper are replaced by a slide switch. Orientation does not matter, and the same holes are used.*

Section 2 – Housing Assembly

Read these steps carefully. Failure to do so will result in a leaky sensor, and a likely malfunction. Take your time, and consult your tool safety manuals before proceeding.

In the following steps, a hand drill and various drill bits will be used. Make sure that the drill bits are sharp, properly installed in the chuck, and you have a secure mounting solution to hold your parts in place. There are curved, slippery surfaces that will be drilled. This type of surface can lead to a drill slipping off course and damaging whatever is in the path of the drill bit. To counteract this scenario, don't apply much pressure with the drill. Let the bit do the cutting. Make an indentation on the plastic before drilling to locate the drill bit if the appropriate tools are available.

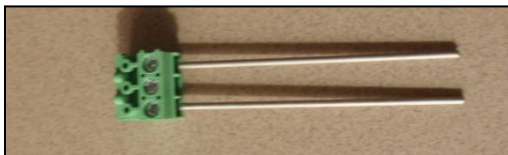
When the housing is complete and the epoxy is dry, it is recommended that the water resistance be tested. Install a tube with a binder clip on the hose barb and close the container. Lower it to a target depth, and let it sit for some time. If the container is dry inside when extracted, this depth will be a safe operating depth.

Fabricate the housing

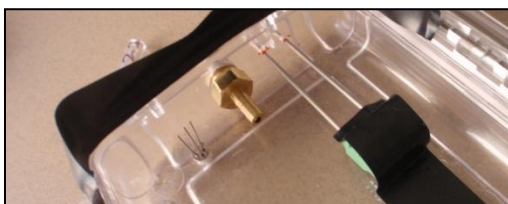
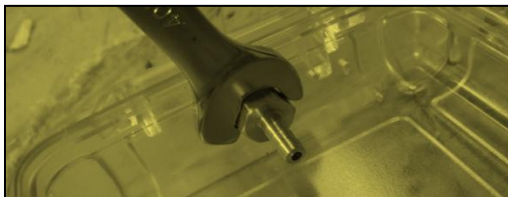
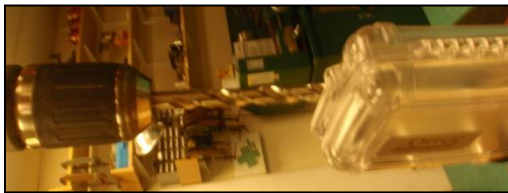
The final sheet of this manual is a template for drilling and installing the sensor probes.

Remove this page and cut out the template. If the template is the wrong size, print the sheet again and select “do not scale” or equivalent from the print settings. Apply the template to the housing with tape as indicated on the template and drill the four indicated holes.

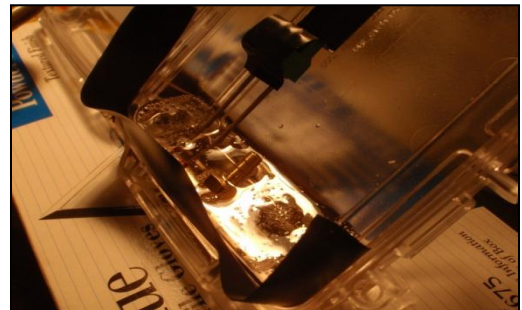
- You will need the following components:
 - 1/8” Hose Barb
 - 2 x 3” x 1/16” Titanium Rods
 - LM35 Temperature Sensor
 - 3 Contact Green Terminal Block



- Install the terminal block on the titanium rods in holes one and three. Skip hole two.



- Note the orientation of the temperature sensor. When looking into the box from the top, with the probes facing away from you, the small tab on the sensor faces up and to the right.



- Test fit the sensor board to make sure all of the sensors and their respective connectors will line up. Tape components in place if they will move during epoxy filling.
- Prop the installed housing probe assembly up at an angle of approximately 75 degrees, an angle that allows for the epoxy to cover all of the sensors.
- Tape over the plastic lip of the container that will mate with the o-ring on the other side of the container to prevent epoxy overflow. It is essential that no epoxy get on this seal, as it may compromise the depth rating of the housing.
- Thoroughly mix the epoxy, and ensure that when the housing is filled, the hose barb and at least 1cm of wire from the temperature probe is left exposed.
- Fill the container as shown in the picture

Section 3 – Installing the software

The following steps require a PC (Linux, Apple, or Windows), along with the following free downloads. The files are also stored on the memory card if supplied by MIT.

- Arduino 0017 (<http://www.arduino.cc/en/Main/Software>, and on MicroSD)
- FileLogger.V0.6.zip (<http://code.google.com/p/arduino-filelogger/>, and on MicroSD)
- Data.log (seaperch.MIT.edu, and on MicroSD)
- Program.pde (seaperch.mit.edu, and on MicroSD)

Check the Sea Perch website for version information:

SeaPerch.MIT.edu

Setting up your MicroSD Card

Install the card in any MicroSD reader. If provided by MIT Sea Grant, copy all of the files off of the card to a new directory on your computer. Format the card in the Fat16 file system. You can search Google for information regarding this procedure and your computer.

Once complete, if provided by MIT, copy the file “data.log” to the card and safely eject the card.

If not provided by MIT, create a file called “data.log” by opening a text editor and selecting the save as function. Write a single “0” (zero) in the file and save. Check that the file does not have a hidden extension such as “.txt” following the “.log.” If it does, remove it. Google will provide information on this procedure based on your computer type.

This file is also available from the MIT Sea Perch webpage (seaperch.mit.edu)

Installing the Programming Environment and Libraries

First install the Arduino programming environment. When complete, navigate to the folder containing libraries (on windows: installation_directory/arduino-0017/hardware/libraries) and copy the unzipped “FileLogger” folder into this directory.

Connect your Arduino microcontroller to the PC via USB *out of the housing*.

Launch the program and select the following from the *tools* menu

- Tools -> Board -> Arduino Duemilanove
- Tools -> Serial Port -> your serial port

If you are unsure of your serial port, guess and check is an appropriate method of determining this information.

Check that the FileLogger library installed correctly by verifying that FileLoggerDemo exists in the following location

- File -> Examples -> FileLogger -> FileLoggerDemo

If all checks out okay, continue to the next step.

Installing the Software on the Arduino

Open the Program.pde file with the Arduino program (downloaded from the internet or provided on the MicroSD card).

Verify that all the above steps were performed correctly

Without the sensor installed, click on

- File -> Upload to I/O board

If you receive errors, check the serial port and board selection and try again.

Once the program compiles, the status box will indicate “Upload Complete.”

Section 4 - Testing the Sensors

Unplug the USB cable and external power from the Arduino and install the sensor board in the housing. Insert your formatted MicroSD card with data.log copied onboard, and install the jumper on the power pins.

A red LED will illuminate indicating power is connected; shortly thereafter the other LED will begin to blink. This indicates that the data is being recorded. After several iterations of blinks, remove the power jumper and the MicroSD card. Open the file created on your computer and check that values were recorded. Conductivity should read zero, as should pressure. Install a 10 Ohm resistor temporarily in the two holes near the conductivity probe and repeat the test. Optionally you can blow into the tube connected to the pressure sensor at the same time. Check your data again. You should now see a somewhat consistent value for conductivity, and a change in the pressure reading.

Section 5 – Calibration

The thermistor, pressure sensor, and light sensor should be calibrated from the factory. Nothing needs to be done with these probes.

Conductivity Calibration

Install the 10 Ohm resistor in the two holes nearest the conductivity probe. Hold the B1 button during startup. Release when both LEDs blink in unison. The sensor is now calibrated. Press the reset button to begin taking data.

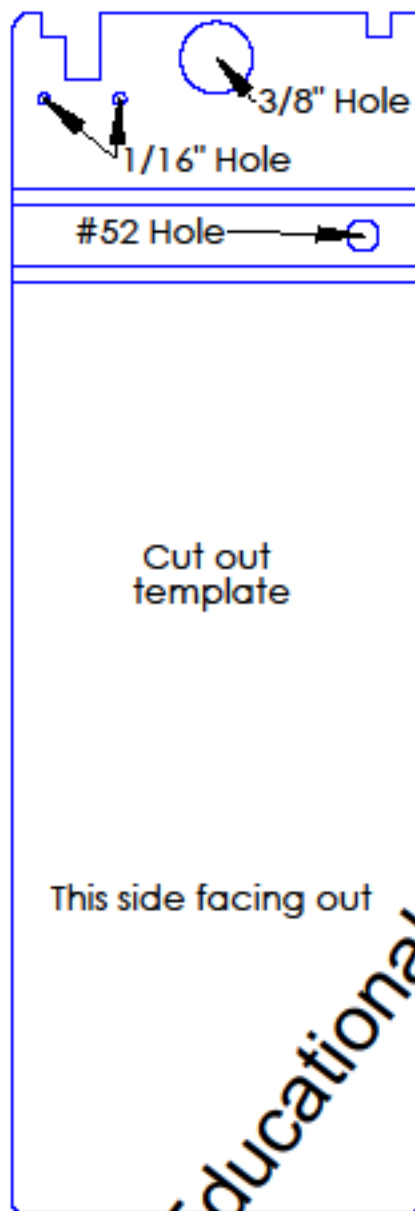
MIT Sea Perch Sensor Suite
V 2.4.1

| Number | Units to buy for One Kit | Minimum Price per Kit | Part Name | Part Supplier | Cost Per Kit (prorated) | Number per Kit | Package Contains | Price | 010 - 099 | Link |
|-----------------|--------------------------|-----------------------|----------------------------------|---------------|-------------------------|----------------|------------------|----------|-----------|---|
| BOB-00544 | 1 | \$ 14.95 | Breakout Board microSD | sparkfun | \$ 14.95 | 1 | 1 | \$ 14.95 | \$ 13.46 | http://www.sparkfun.com |
| COM-09273 | 1 | \$ 0.95 | 555 Timer | sparkfun | \$ 0.95 | 1 | 1 | \$ 0.95 | \$ 0.86 | http://www.sparkfun.com |
| COM-00097 | 2 | \$ 0.70 | Mini Push Button Switch | sparkfun | \$ 0.70 | 2 | 1 | \$ 0.35 | \$ 0.32 | http://www.sparkfun.com |
| PRT-09374 | 2 | \$ 1.00 | Arduino Stackable Header - 8 Pin | sparkfun | \$ 1.00 | 2 | 1 | \$ 0.50 | \$ 0.45 | http://www.sparkfun.com |
| PRT-00116 | 1 | \$ 2.50 | Break Away Headers - Straight | sparkfun | \$ 2.50 | 1 | 1 | \$ 2.50 | \$ 2.25 | http://www.sparkfun.com |
| PRT-07937 | 2 | \$ 3.00 | DIP Sockets Solder Tail - 8-Pin | sparkfun | \$ 3.00 | 2 | 1 | \$ 1.50 | \$ 1.35 | http://www.sparkfun.com |
| COM-00107 | 1 | \$ 1.25 | Voltage Regulator - 5V | sparkfun | \$ 1.25 | 1 | 1 | \$ 1.25 | \$ 1.13 | http://www.sparkfun.com |
| DEV-00666 | 1 | \$ 29.95 | Arduino USB Board | sparkfun | \$ 29.95 | 1 | 1 | \$ 29.95 | \$ 26.96 | http://www.sparkfun.com |
| COM-09609 | 1 | \$ 0.75 | SPDT Slide Switch | sparkfun | \$ 0.75 | 1 | 1 | \$ 0.75 | \$ 0.68 | http://www.sparkfun.com |
| COM-08375 | 2 | \$ 0.50 | Capacitor Ceramic 0.1uF | sparkfun | \$ 0.50 | 2 | 1 | \$ 0.25 | \$ 0.23 | http://www.sparkfun.com |
| SEN-08940 | 1 | \$ 5.95 | Light Intensity to Frequency IC | sparkfun | \$ 5.95 | 1 | 1 | \$ 5.95 | \$ 5.36 | http://www.sparkfun.com |
| 785378 | 1 | \$ 7.99 | 2gb Micro SD Card | Microcenter | \$ 7.99 | 1 | 1 | \$ 7.99 | \$ 7.99 | http://www.microcenter.com |
| 428342 | 1 | \$ 3.99 | Micro SD card reader | Microcenter | \$ 3.99 | 1 | 1 | \$ 3.99 | \$ 3.99 | http://www.microcenter.com |
| 651-1933192 | 1 | \$ 0.27 | Terminal Blocks PST 1.3/3-5.0 | Mouser | \$ 0.27 | 1 | 1 | \$ 0.27 | \$ 0.27 | http://www.mouser.com |
| 651-1934874 | 1 | \$ 0.47 | Terminal Blocks PT 1.5/3-PVH-5.0 | Mouser | \$ 0.47 | 1 | 1 | \$ 0.47 | \$ 0.47 | http://www.mouser.com |
| 638-MV5764.MP48 | 2 | \$ 0.62 | LED Circuit Board Indicators T-1 | Mouser | \$ 0.62 | 2 | 1 | \$ 0.31 | \$ 0.31 | http://www.mouser.com |
| CB002 | 1 | \$ 20.00 | circuit board | MIT | \$ 20.00 | 1 | 1 | \$ 20.00 | \$ 15.00 | http://seagrant.mit.edu |
| MPX4250AP-ND | 1 | \$ 15.84 | MPX4250AP-ND PressureProbe | Digikey | \$ 15.84 | 1 | 1 | \$ 15.84 | \$ 15.84 | http://www.digikey.com |
| LM35CAH-ND | 1 | \$ 14.52 | LM35CAH-ND Temp Probe | Digikey | \$ 14.52 | 1 | 1 | \$ 14.52 | \$ 14.52 | http://www.digikey.com |
| 399-4261-ND | 2 | \$ 0.50 | 0.01uF capacitor | Digikey | \$ 0.50 | 2 | 1 | \$ 0.25 | \$ 0.25 | http://www.digikey.com |
| 1.2KQBK-ND | 5 | \$ 0.32 | 1.2K ohm resistor | Digikey | \$ 0.32 | 5 | 1 | \$ 0.06 | \$ 0.06 | http://www.digikey.com |
| 3.3KQBK-ND | 5 | \$ 0.32 | 3.3K ohm resistor | Digikey | \$ 0.32 | 5 | 1 | \$ 0.06 | \$ 0.06 | http://www.digikey.com |
| 330QBK-ND | 1 | \$ 0.32 | 330 ohm resistor | Digikey | \$ 0.13 | 2 | 5 | \$ 0.32 | \$ 0.32 | http://www.digikey.com |
| 110QBK-ND | 1 | \$ 0.32 | 110 ohm resistor | Digikey | \$ 0.06 | 1 | 5 | \$ 0.32 | \$ 0.32 | http://www.digikey.com |
| 10QBK-ND | 1 | \$ 0.32 | 10 ohm resistor | Digikey | \$ 0.06 | 1 | 5 | \$ 0.32 | \$ 0.32 | http://www.digikey.com |
| 2000-01-SJ | 1 | \$ 17.95 | ob 2000 clear | otterbox | \$ 17.95 | 1 | 1 | \$ 17.95 | \$ 17.95 | http://www.otterbox.com |
| 89145K283 | 1 | \$ 5.38 | titanium - 1/16" grade 2 | McMaster | \$ 0.90 | 6 | 36 | \$ 5.38 | \$ 5.38 | http://www.mcmaster.com |
| 9657K86 | 1 | \$ 7.85 | Brass Compression Spring | McMaster | \$ 1.31 | 2 | 12 | \$ 7.85 | \$ 7.85 | http://www.mcmaster.com |
| 5346K61 | 1 | \$ 7.57 | 1/8" hose barb - brass | McMaster | \$ 0.76 | 1 | 10 | \$ 7.57 | \$ 7.57 | http://www.mcmaster.com |
| 5114K14 | 1 | \$ 7.80 | Beverage Clear Tygon PVC Tubing | McMaster | \$ 0.78 | 1 | 10 | \$ 7.80 | \$ 7.80 | http://www.mcmaster.com |
| 8870A14 | 1 | \$ 1.05 | 1/16" drill bit | McMaster | \$ 1.05 | 1 | 1 | \$ 1.05 | \$ 1.05 | http://www.mcmaster.com |
| 8870A36 | 1 | \$ 4.86 | 3/8" drill bit | McMaster | \$ 4.86 | 1 | 1 | \$ 4.86 | \$ 4.86 | http://www.mcmaster.com |
| 7541A77 | 1 | \$ 5.82 | epoxy | McMaster | \$ 5.82 | 1 | 1 | \$ 5.82 | \$ 5.82 | http://www.mcmaster.com |

| | |
|--------------------|-----------|
| Total (prorated) : | \$ 160.02 |
| Minimum Total: | \$ 185.58 |

Template

Folding Pattern



This side facing out

This side facing out

| | | | | | |
|-------------|---------|--------------------------|--|--------------|------|
| | | DIMENSIONS ARE IN INCHES | | NAME | DATE |
| | | TOLERANCES: | | DRAWN | |
| | | FRACTIONAL ± | | CHECKED | |
| | | ANGULAR: MACH ± BEND ± | | ENG APPR. | |
| | | TWO PLACE DECIMAL ± | | MFG APPR. | |
| | | THREE PLACE DECIMAL ± | | G.A. | |
| | | MATERIAL | | COMMENTS: | |
| NEXT ASSY | USED ON | FINISH | | | |
| APPLICATION | | DO NOT SCALE DRAWING | | | |
| | | | | REV. | |
| | | | | A Template | |
| | | | | SCALE: 1:1 | |
| | | | | WBGHE | |
| | | | | SHEET 1 OF 1 | |

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