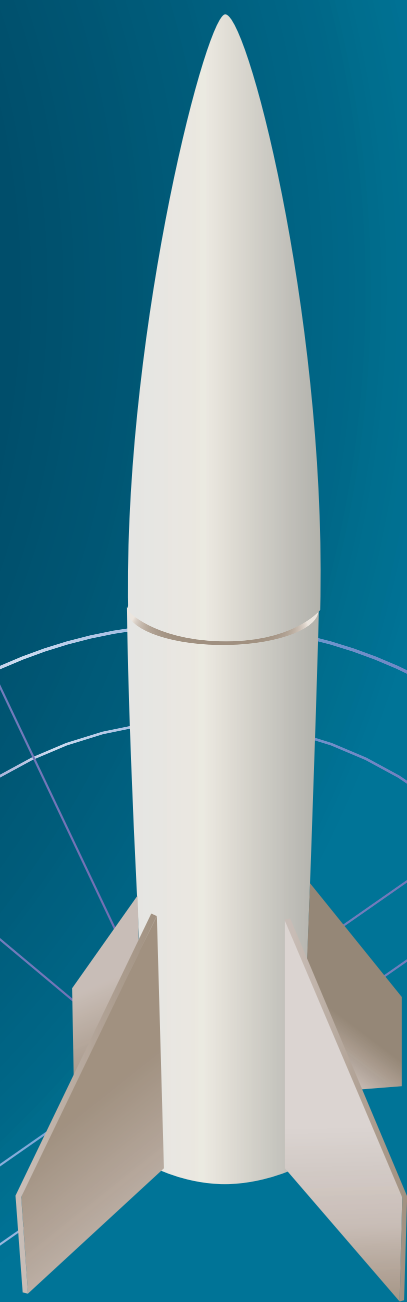
N3 Rocket Guide



Partner

Acknowledgement:

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Reference:

All videos and guides used in N3 are linked here:
http://n3.sonoma.edu/resources

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	Stuff the streamer into the main tube
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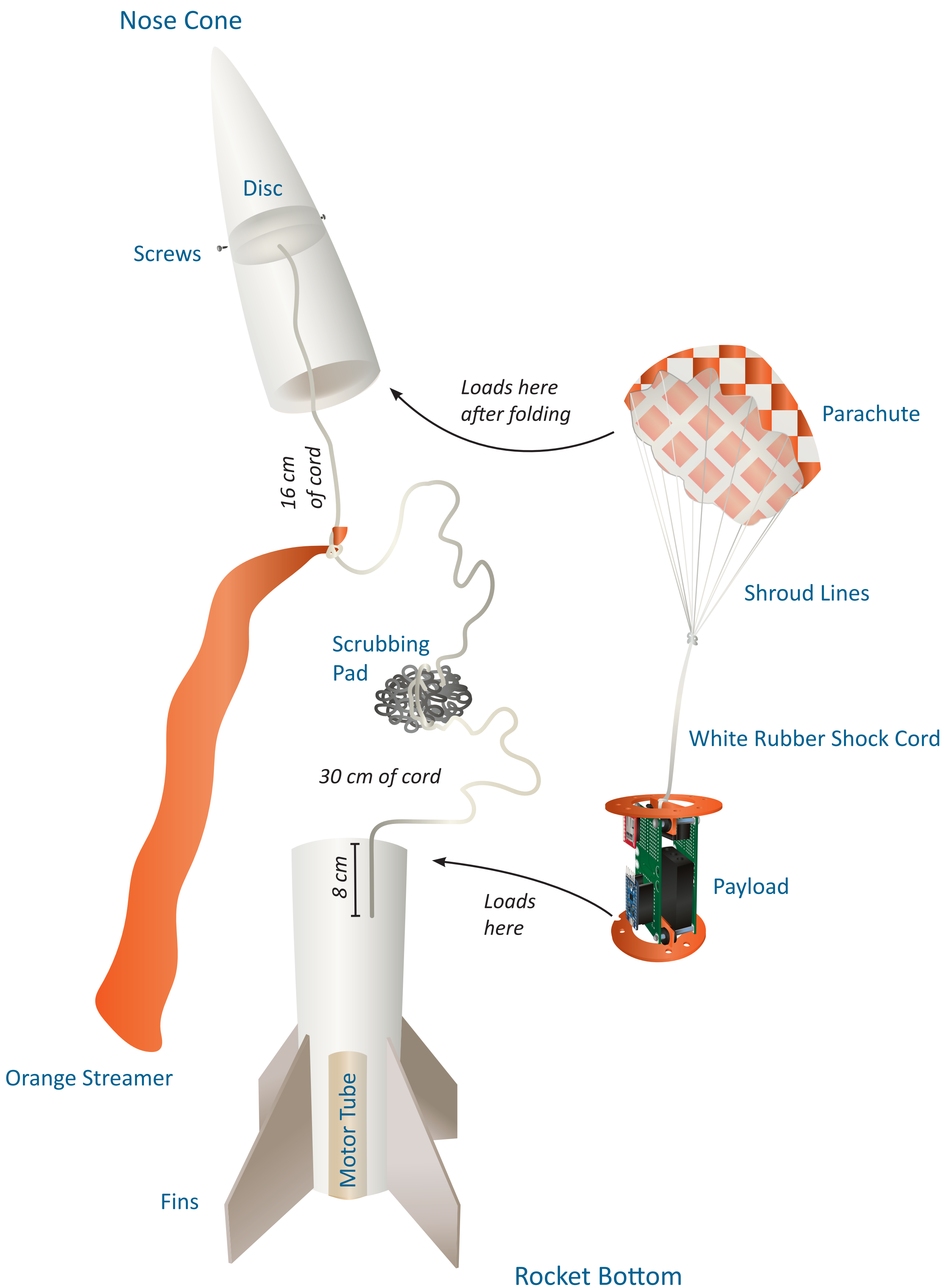
	Congratulations, you are done and ready to launch!

Rocket Assembly Diagram



A. Building the Rocket

Introduction

The steps in this guide are adapted from the video created by Tony Alcocer for NASA's Rising Data program. The video can be viewed here (SSU Rising Data by tfish38):
https://www.youtube.com/watch?v=A4yP8UF8F94

There are several differences between these instructions and the video:

1) We have already cut the bottom of the nose cone off and drilled the holes (shown in the video from 5:30 to 9:30).

2) Please note that the long black shock cord in the video is now a long white cord. There is also a shorter, elastic cord that is part of the rocket kit, half of which is used to connect the payload to parachute (and the other half is not used).

Note: you will not need the yellow and orange tubes provided in the kit.

Material, Tools and Supplies:

Provided:

- Estes Big Daddy Rocket Kit

- Modification parts:
- White disk
- Long white shock cord
- Scrubbing pad
- Orange streamer

- Tools:
- Glue
- Helping hands
- Hobby knife
- Sandpaper
- Stripper/cutter
- Wire

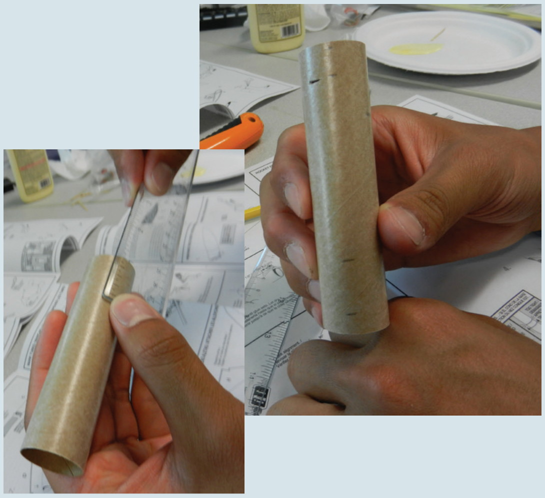
- Needed in addition:
- Pencil
- Ruler
- Scissors
- Tape (scotch, masking or painters)

A.1 Engine Mount

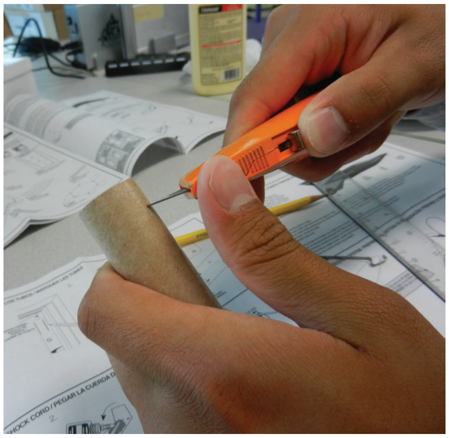
Remove the following from the small plastic bag in the rocket kit:

B Engine mount tube: Light brown tube
D Engine hook: Flat bent metal piece
C Green engine block: Short green tube

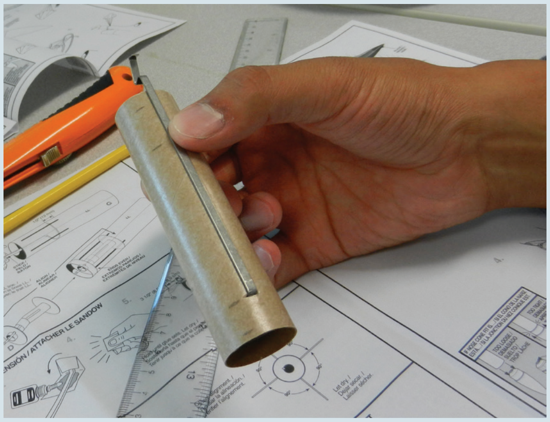
1. Using a ruler measure from one end of the engine mount tube and make marks at 6 mm, 25 mm, 8.9 cm and 9.8 cm.



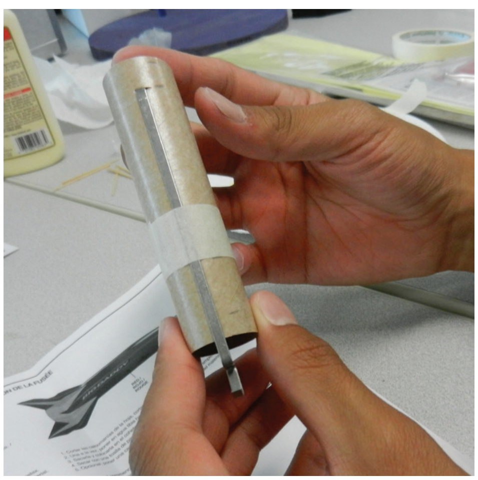
2. Make a small incision with a sharp knife on the third mark (8.9 cm from the bottom).



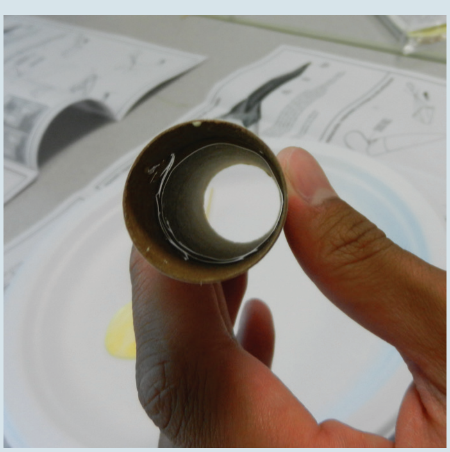
3. Place the end of the engine hook with the 90˚ bend into the incision you just made. Lay the rest of the engine hook against the tube.



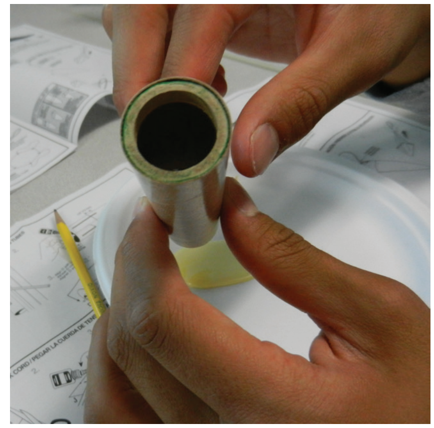
4. Use a piece of masking tape around the engine mount tube at the 25 mm mark to hold the engine hook in place.



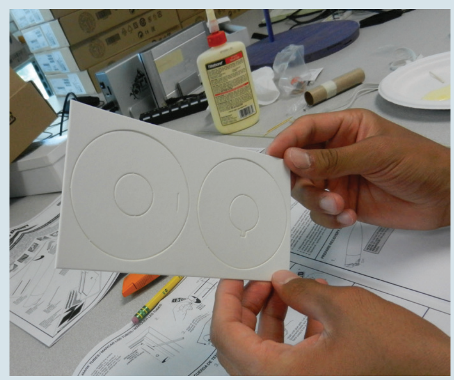
5. At the end of the tube where your 9.8 cm mark is, place a light ring of glue ***inside*** the tube. You should be able to see the engine hook sticking through the tube.



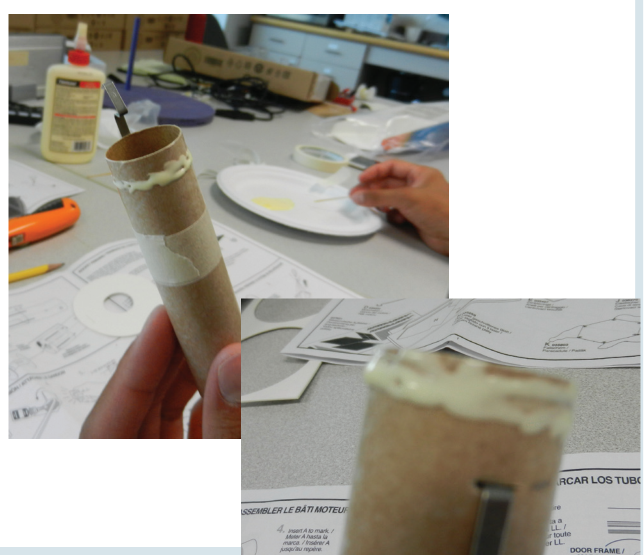
6. Now take the green engine block tube and place it into the glue. Push it down until it contacts the protruding engine hook inside the engine mount tube.



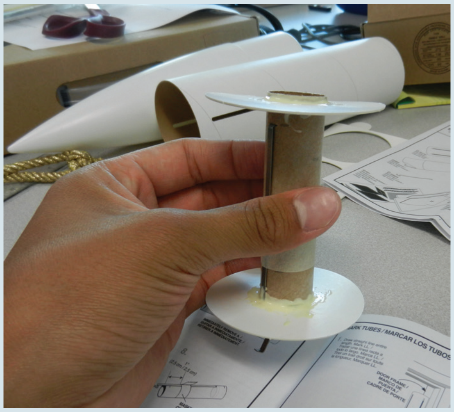
7. Remove the centering rings out of the white cardboard and then remove the center pieces.



8. Place a ring of glue on the first mark (5mm) and the fourth mark (9.8 cm) of the engine motor tube.



9. Insert the brown tube through the centering rings lining them up with the marks on the tube. The notched ring goes on the bottom, and the un-notched ring goes on the top (the end with the green ring). Reinforce with some glue.



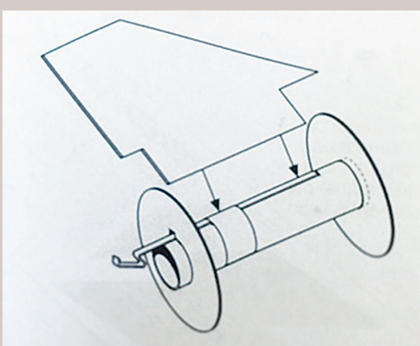
Here is the completed engine mount. LET IT DRY COMPLETELY.

A.2 Preparing Fins

1. Punch out the fins from the balsa wood panels

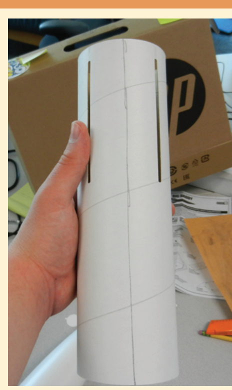
2. Sand the fins as desired.

3. Take the rectangular fin inserts and test to see if they fit perpendicularly between the two centering rings of the engine mount. **Do not glue**!

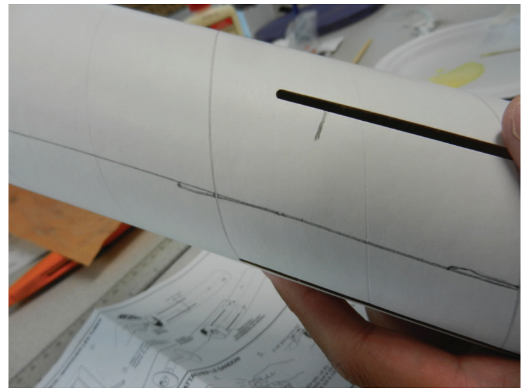


A.3 Insert Engine Mount in Main Tube

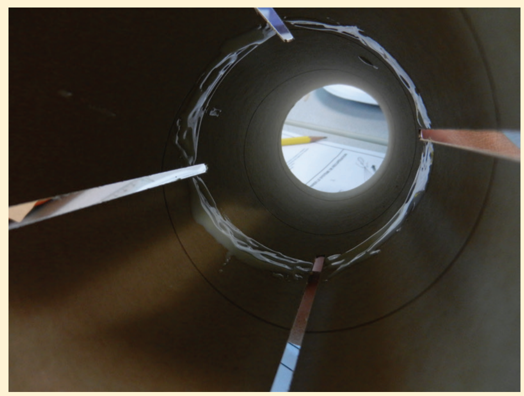
1. Draw a straight line from top to bottom of the main body tube between two of the fin slots.



2. Make a mark 13 mm from the top of the fin slots.

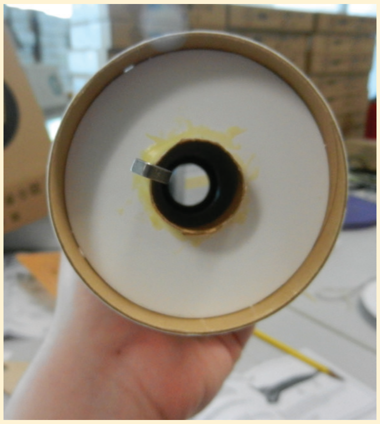


3. Put a ring of glue on the inside of the body tube at the mark. Since it may be hard to reach, you can use a pencil or similar tool to apply the glue.



4. Insert the entire engine mount into the bottom of the body tube. It is in the correct position when the top centering ring of the engine mount is aligned with the previously made mark (13 mm from the top of the fin slots).

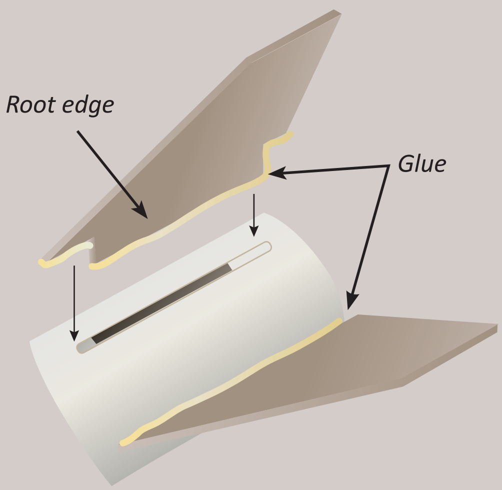
5. NOTE: the engine hook must line up with the straight line made in Step One of this section.



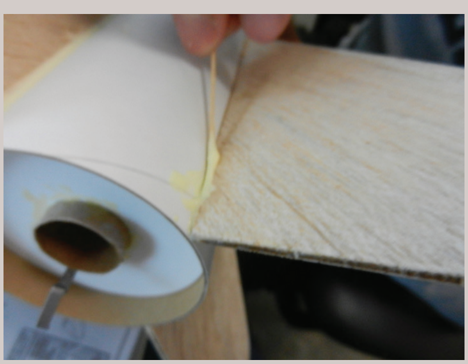
Do Not Install The Shock Cord at this time.

A.4 Glue Fins into Slots in Main Tube

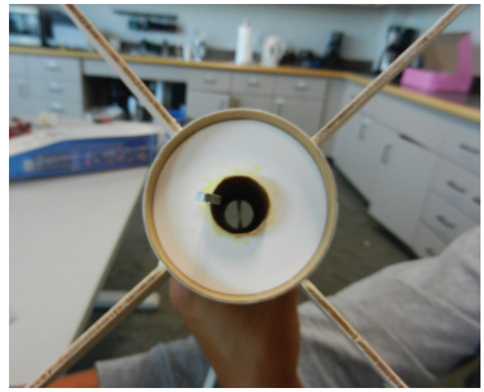
1. Spread glue along the root edge of the fin. Insert the fin into the slot in the body tube and then glue both sides of the fin, where it meets the body tube.



Insert the fins into a fin slot of the body tube.

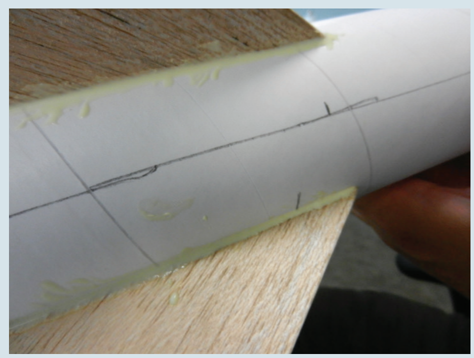


2. Repeat for all four fins. Make sure that each fin is perpendicular to the rocket body.

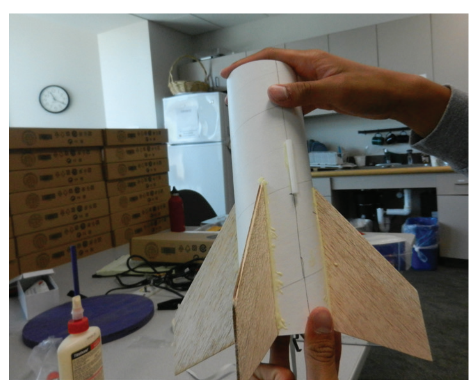


A.5 Attaching Launch Lug

1. Make a mark 11.4 cm from the bottom of the Rocket Body. Make sure that this mark is along the "top to bottom" lengthwise mark you made in a previous section.



2. Apply a dab of glue on the launch lug, and place it on the lengthwise mark, going up from the mark from step one (11.4 cm from the bottom). Use a piece of masking tape to hold this until the glue dries.



Let the glue completely.

A.6 Shock Cord Assembly

1. Insert the disc to one end of the white shock cord (black shown in photos). Tie four or more over-hand knots to secure it.

2. Tie the orange streamer to the shock cord 16 cm from the nose cone.

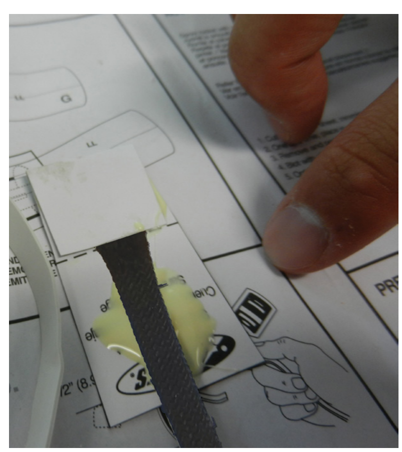
3. Attach the baffle (scrubbing pad) to the other end of the black shock cord at about 30 cm from the end.

Final result of the modification assembly

4. Cut out the strip of paper (which will serve as the shock cord mount) with a pair of scissors.

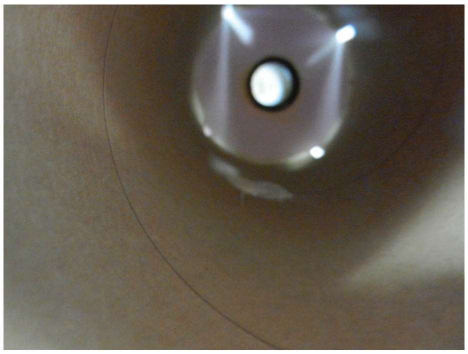
5. Place a dab of glue on the second section of the piece of paper, and place one end of the black shock cord on the glue.

6. Fold the first section on the second and let dry.



7. When dried, place a dab of glue on the third section and fold the folded first and second sections on the third section.

8. Next, place a dab of glue on the inside of the white tube, 8.9 cm from the top.



9. Place the paper shock cord mount onto the dab of glue on the inside of the rocket and let dry.

A.7 Nose Cone Fit and Disk Insertion

1. Checking the nose cone.
Take one of the orange sleds and slide it into the nose cone. If it does not easily slide in and out, use sandpaper to smooth the inside of the nose cone until it easily slides in and out.

2. Inserting the disk
Insert the white disk that is attached to the shock cord into the nose cone until it fits tightly. Screw the disk in place using the holes that were pre-drilled in the nose cone.

(Note: the disk does not have any holes drilled into it, but the screws will hold the disk in place if it is properly placed.)

B. Building the Payload

A payload is made of all the electronic components that are needed to acquire scientific data during the rocket's flight. This usually includes some type of micro-computer, some sensors, a method to save the scientific data and a power system. The N3 payload has two circuit boards to which you are going to solder components. The Experiment board includes the Arduino micro-controller, Nine-Degrees-of-Freedom (9DoF) and temperature sensors, and an SD card that stores the data during flight. The Battery Board includes the battery pack, an on/off switch and a voltage regulator.

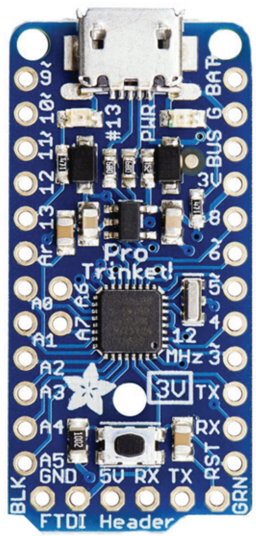
B. 1 Getting Ready to build the Payload Boards

B.1.a Parts Used in Experiment and Battery Boards

This section shows images and describes each of the parts used in the Experiment Board and the Battery Board.

Parts for the Experiment Board:

Arduino Pro Trinket 3V

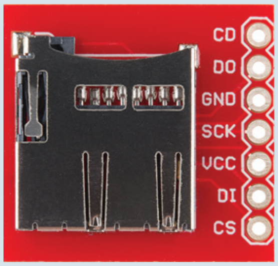


This device provides the processing power for the payload. It uses an ATMega328 Processor that runs regular Arduino C/Processing Code written with the Arduino IDE (Integrated Development Environment). While this device has a USB Port capable of powering the device and loading code, it does NOT have an on-board FTDI chip with which many other Arduinos come equipped. This means that in order to have serial communication with the device, it is necessary to use an FTDI cable instead of a regular USB cable.

There are two versions of the Pro Trinket: one uses 3.3V and the other uses 5V. For Rising Data, we are using 3.3V, so be careful if ordering additional boards. The 5V has (almost) identical pins, and all the documentation provided by the manufacturer is for the 5V version. Don't let this confuse you.

Instructions for testing the Arduino are in sections B.2.a Arduino.

MicroSD Card Device

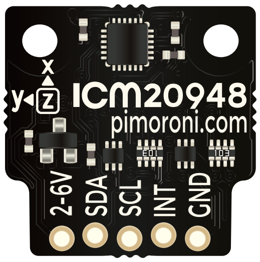


This device provides mechanical and electrical connections to the pins on a micro SD card. and a mechanical socket for the SD card.

This device connects to the Arduino to quickly log data as we collect it. The software allows us to write to SD card, so it can be removed and read as a text file from a computer.

Instructions for wiring and testing the SD Card are in section B.2.b SD card.

9DoF Device (Nine Degrees of Freedom)



This device incorporates three sub-sensors: a 3-axis accelerometer, a 3-axis gyro, and a 3-axis magnetometer. These sensors provide data to analyze after flights.

Instructions for wiring and testing the 9DoF are in section B.2.c 9DoF.

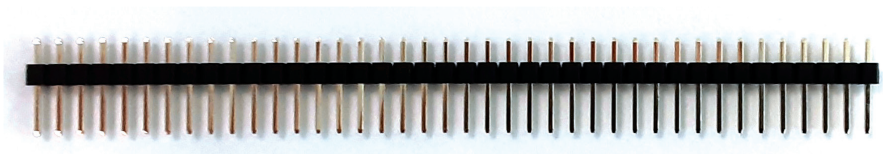
FTDI cable

The FTDI is a special type of USB cable that is used to communicate with the Experiment Board.

Male header pins

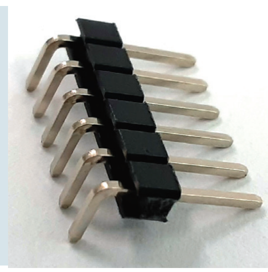
This strip of 40 male pins should be snapped into pieces:

- two 12-pin pieces
- one 7-pin piece
- one 5-pin piece
- one 4-pin piece

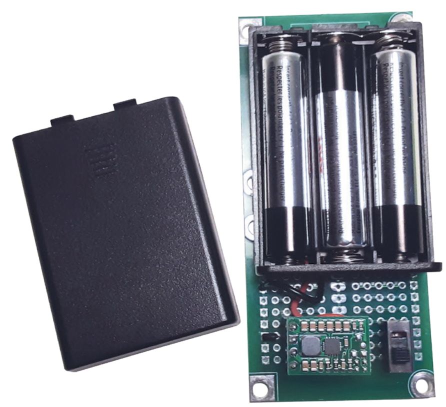


90 degree six-pin male header

This special six pin-male header is used to connect the Arduino to the FTDI cable.



Parts for the Battery Board:

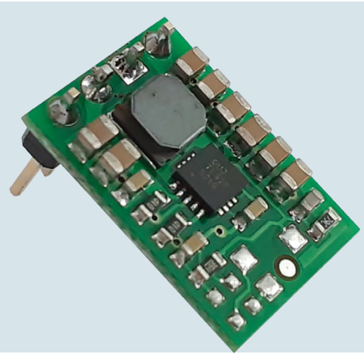


Battery pack

The battery pack holds 3 AA batteries and provides wires to attach to power and ground.

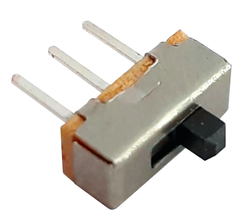
Voltage regulator

The voltage regulator converts the 4.5 V output from the 3 AA batteries to a stable 3.3V source of power for the Experiment Board.



Switch

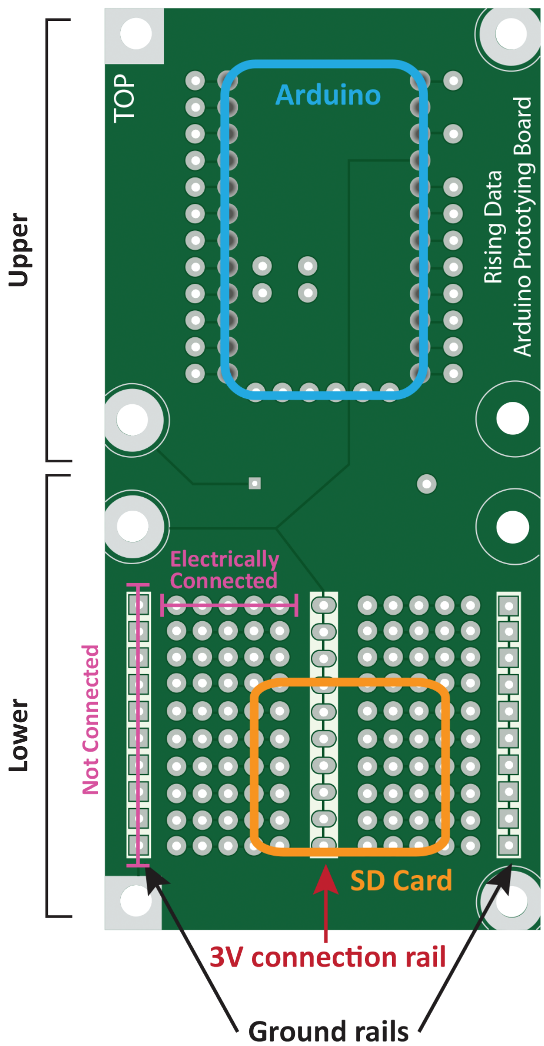
The switch is used to turn on and off the power from the Battery Board to the Experiment Board.



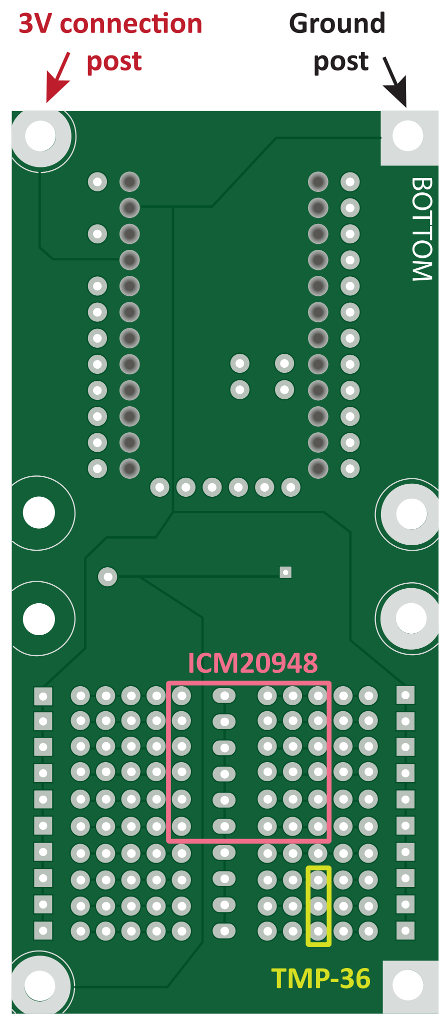
Protoboard

These green circuit boards are custom designed for the Rising Data project and are now being used by N3. On the top side of the board, there are special areas for soldering the socket that holds the Arduino (upper) and SD card (lower). On the bottom side of the board, the 9DoF and TMP-36 sockets can be soldered in the lower area. There is also room for additional devices in this lower area. Note that there are traces built into the board that connect the power and ground pins for the Arduino to the inside and outside rails, respectively. There are also holes in all four corners of the board that connect to metal posts to build the structure that comprises the payload. Some of the posts are connected to ground, and others to 3V power supplied by the battery board.

Top Side

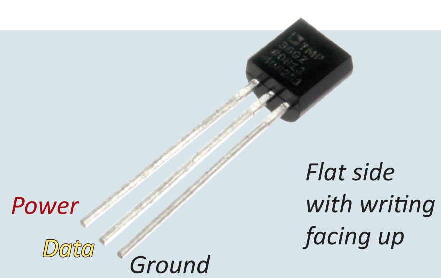


Bottom Side



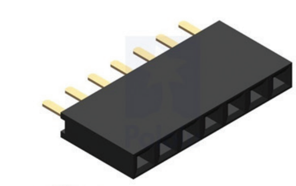
TMP-36

The TMP-36 is a relatively linear analog device, which means that the voltage it puts out is proportional to the ambient temperature. It has three pins: Power, data and ground.



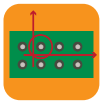
Female Header Socket

We will be attaching all our parts using rows of female header sockets so that parts can be easily attached and removed from the protoboard. These will be soldered to the protoboard (instead of soldering the parts themselves).



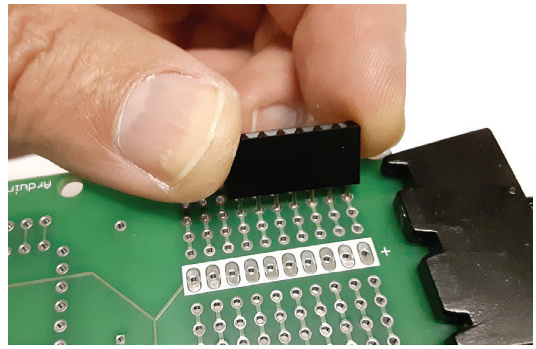
B.1.b General Assembly Instructions

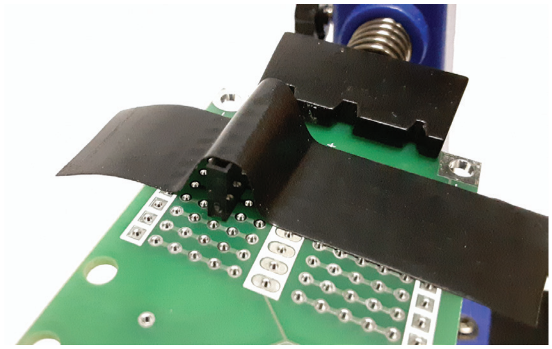
For some of the components, you will be soldering female sockets onto the protoboard. These sockets will be connected by wires to other places on the protoboard. Here are some tips for how to do this more easily:

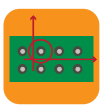


Place Socket

Put the part through the holes you intend to solder it into. You may also decide to tape the part in place so it doesn't fall out when you pass it off to have it checked or when you move it around to solder it.

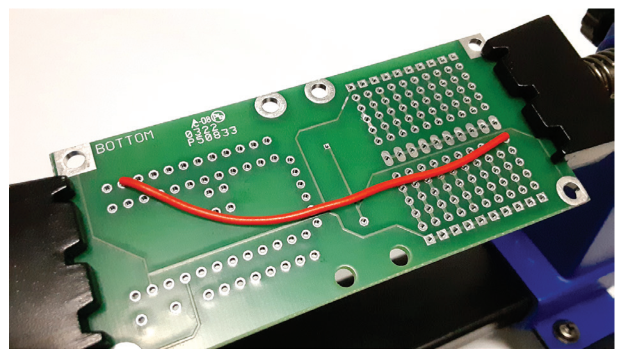






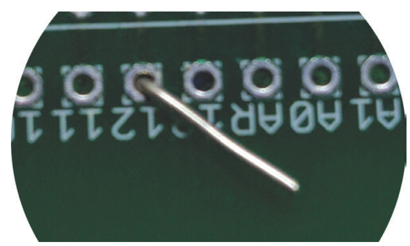
Wiring Placement

First cut the wires to the desired length. You want the wire to fit comfortably between the two pins it connects, but you don't want enough extra slack that it could get snagged when being handled. Be sure to leave about an extra inch past what you need for the next step (stripping the ends).



Strip about ½ inch off each end of the wire so you can connect it to the board with solder.

After putting the wires through the appropriate holes, fold them over as shown. This will keep them from falling out in the time between placing them and soldering them.



Checks

If possible, pass the payload to a partner to have them confirm your placement. This step is critical to avoid mistakes that are very difficult to reverse. You should be checking the placement against the images in this document. Make sure that parts are placed one row over from the edge, to allow the ground jumper pins to be connected as shown in the diagrams.

Check that the part is being placed through the correct face (top or bottom) of the board. The top and bottom of the board are labeled. Placing the part through the wrong face will prevent the payload from operating.

Solder

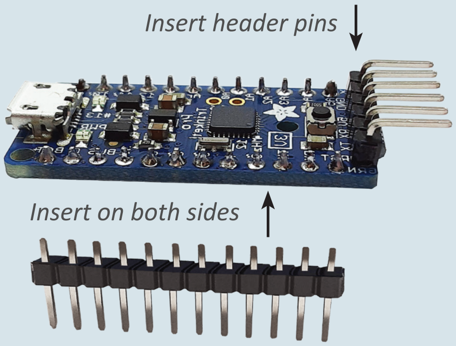
This is the step in which you will solder parts in place.

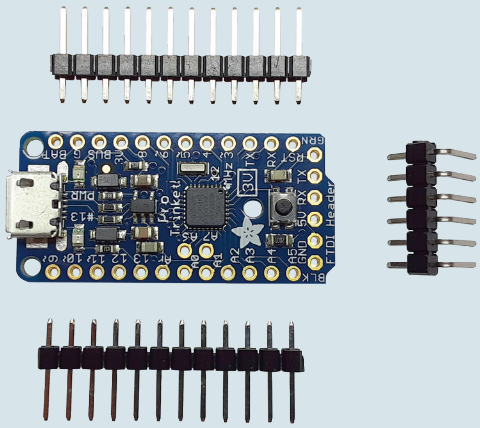
B.1.c Soldering Header Pins

Four components need to have male header pins soldered onto them before they will fit into the sockets (that will later be soldered onto the protoboards): the Arduino, the 9DoF, the SD card holder and the power regulator.

Solder Header Pins onto Arduino:

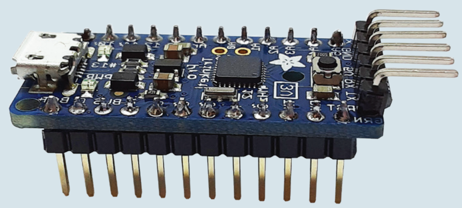
The Arduino needs two 12-pin and one 90-degree six-pin header pins. Break off two 12-pin lengths from the 40-pin sticks that are provided in your kit. The longer pin side of each stick will eventually be plugged into sockets soldered onto the green protoboard, and the shorter pin side will be soldered to the Arduino itself.



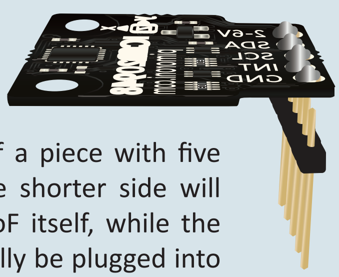


Solder each of the two 12-piece header pins onto the sides of the Arduino facing downwards.

Solder the 90-degree 6-piece header pins along the bottom of the Arduino facing upwards.



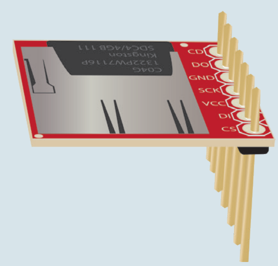
Solder Header Pins onto the 9DoF:



For the 9DoF, break off a piece with five header pins. Again, the shorter side will be soldered to the 9DoF itself, while the longer side will eventually be plugged into sockets on the green protoboard.

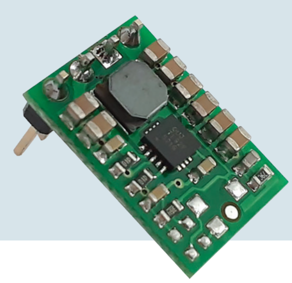
Solder Header Pins onto the SD Card Reader:

For the SD card reader, break off a piece with 7 header pins. Again, the shorter side will be soldered to the SD card itself, while the longer side will eventually be plugged into sockets on the green protoboard.



Solder the power regulator Pins:

The power regulator uses the remaining four pin male header. Solder the short pin side to the regulator chip.

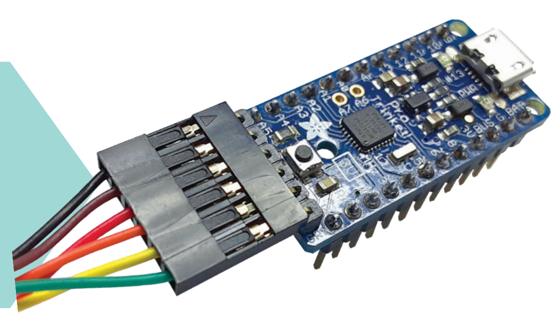


B.1.d Testing the Arduino

1. Connect the FTDI Cable to the 90-degree header pin that was soldered onto the Arduino. Plug the other end of the cable into the computer.

FTDI Pins: Connect FTDI Header to header pins on the Arduino as shown in the image:

Note: Physicists might find it easy to remember the order as Black, Brown, [R,O,Y,G] when going from left to right.



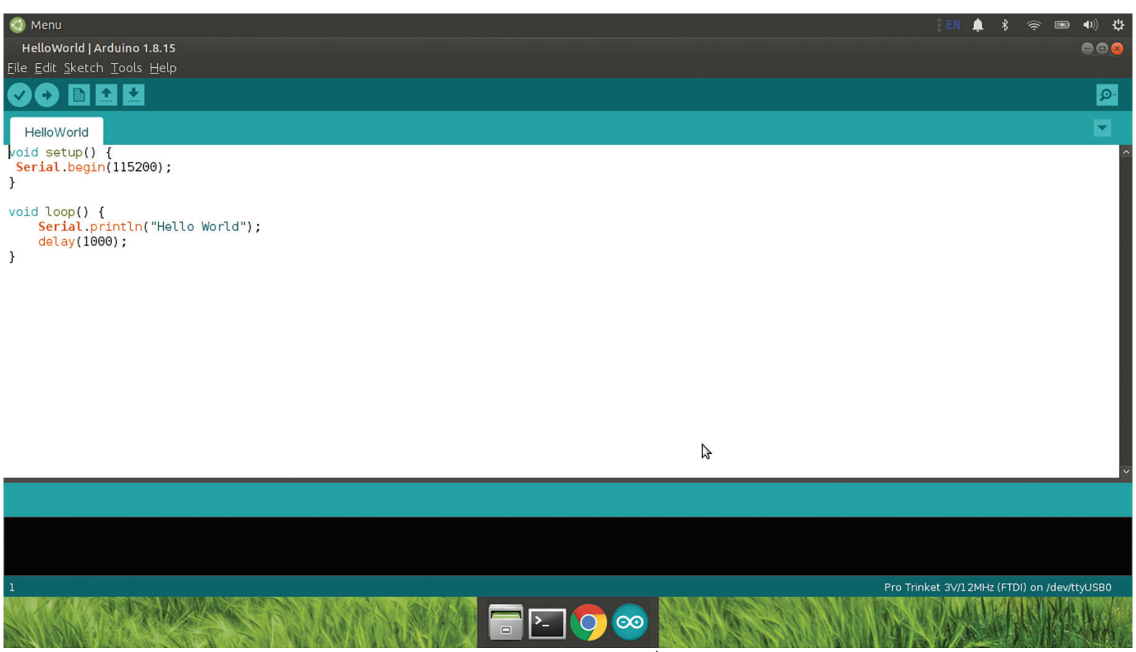
FTDI USB: Connect the USB side of the cable to your computer's USB port.

2. Launch the Arduino IDE

Power on the HP Stream by pressing the button on the upper left-hand side of the keyboard.
Hit the Enter key to login as LbyM (no password is needed).
Once you are logged in, the screen should look like this:

If the computer is idle for too long, it may prompt you for a password. If so, enter 1qazxsw2 to log back in.

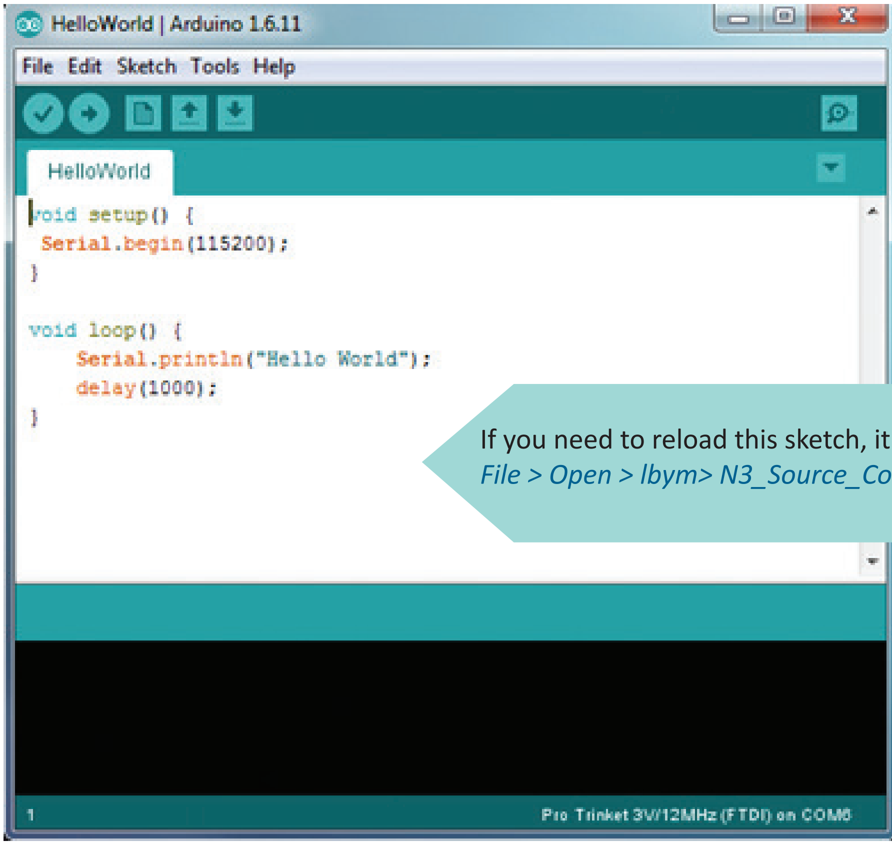
Click on the symbol for the Arduino IDE (Interactive Development Environment). It will launch the IDE, open the Hello World sketch, and the screen will look like this:



IDE icon

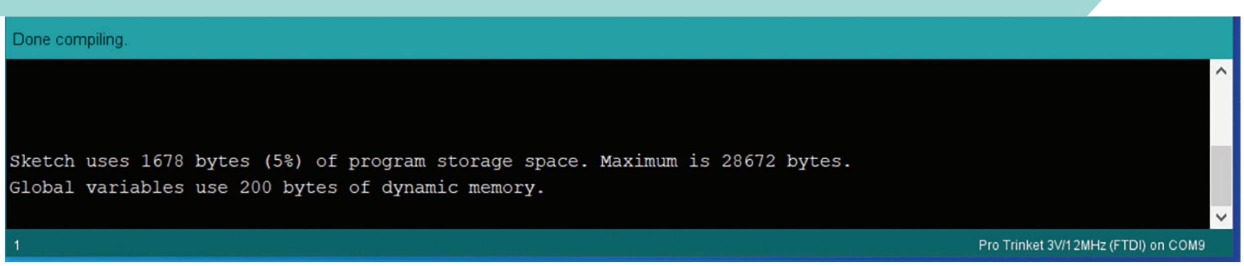
3. The "Hello World" Sketch:

HelloWorld is a very simple program is designed to communicate "Hello World" over the serial connection between the Arduino and the computer. Compiling, loading, and running this sketch will show us that the serial communications are working correctly.



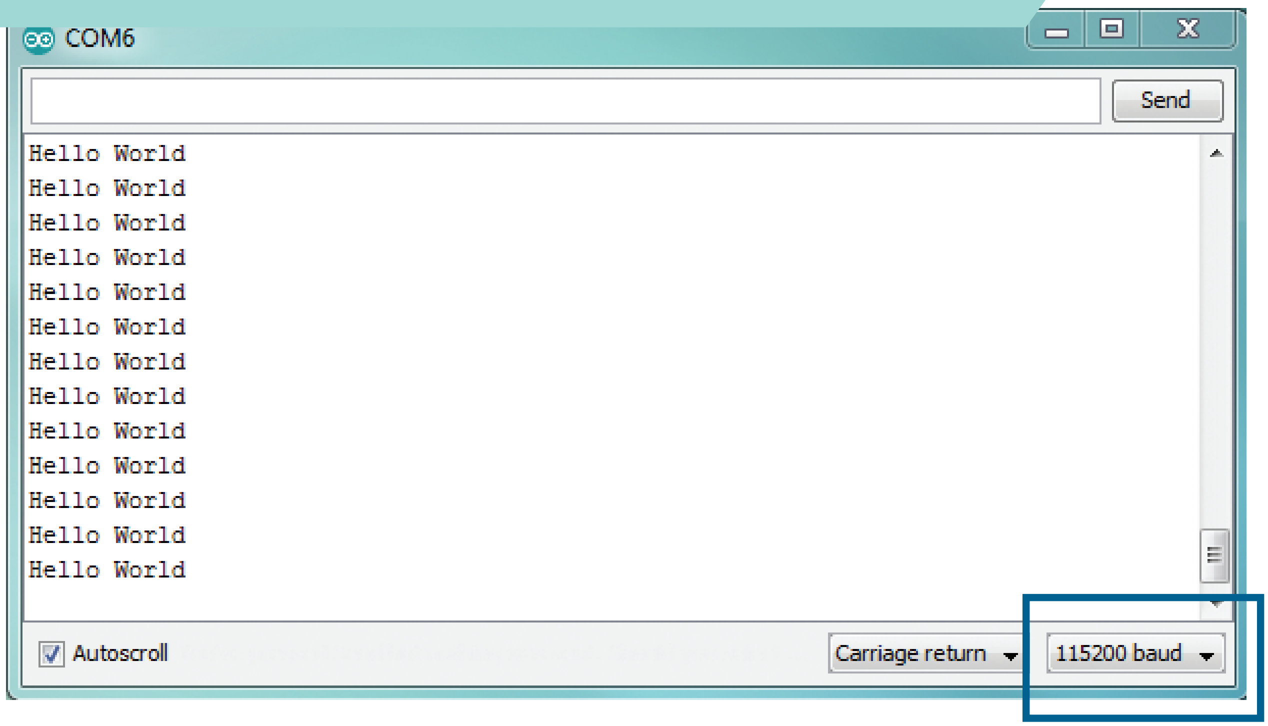
If you need to reload this sketch, it is found at:
File > Open > lbym> N3_Source_Code > src > HelloWorld > HelloWorld.ino

4. Compile and Upload: Compile and upload the code to your device by pressing 
When finished, you should see the following at the bottom of your window:



5. Open the Serial Monitor: Open by pressing 

Check to make sure the baud rate (bottom right corner) is set to the value of 115200. You should see "Hello World" written to the screen at a rate of once per second. This means everything is working and we are ready to start testing the other chips once they are plugged and wired into the protoboard.

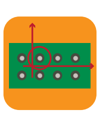


B. 2 Experiment Board

The Arduino Pro Trinket (3.3V) microcontroller is the brain of the Experiment Board. The Arduino receives input from the 9DoF and TMP-36 sensors and writes the data to the SD Card. In this section, you will solder sockets for each of these devices onto the board, solder wires to specific pins on each socket to the sensor outputs, control lines, and to power and ground on the protoboard. After installation, you will run the software for each new device to verify operation. If the device does not operate properly, please consult the troubleshooting section of the guide.

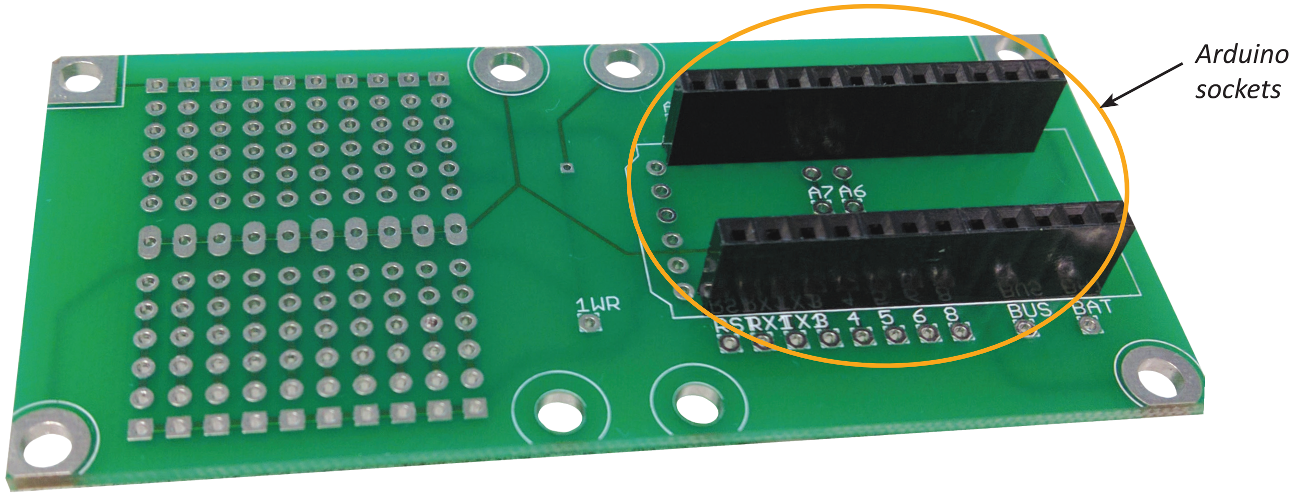
B.2.a Arduino

In this section, we will connect the Arduino to the protoboard. If you have not already done so, unplug the Arduino Pro Trinket from the FTDI cable. You will first connect the header socket rows ("sockets") to the protoboard, then you will plug the Arduino in and repeat the software test that you ran in the previous section ("Hello world").



Place sockets

Insert the two 12-pin female sockets into the protoboard as shown. Note that they should go through the innermost pair of hole rows. Also note that the sockets go into the top side of the protoboard. Put tape over the sockets to hold them in place when you turn the board over to solder it in place.



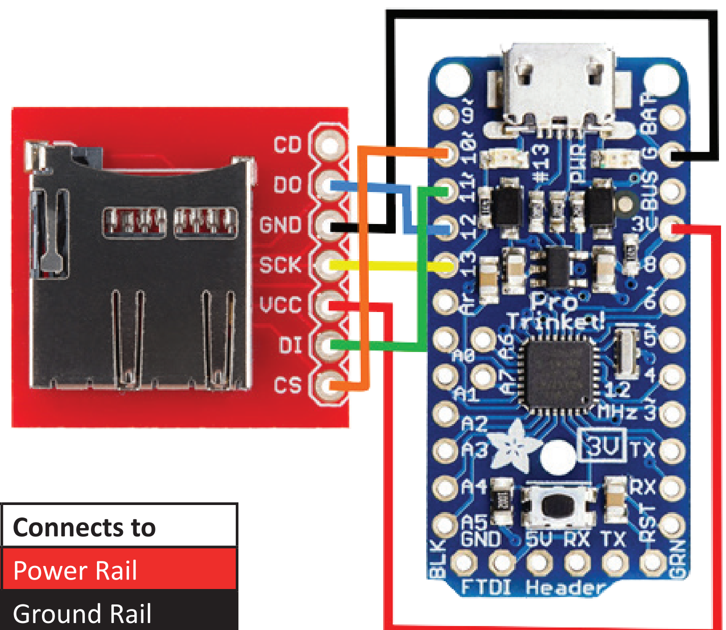
Check
Have a partner check your work by plugging the Arduino into the sockets to ensure it fits.

Solder
Turn the board over, and solder both sockets in place.

Test Software
Connect the FTDI cable to the Arduino and repeat the Hello World software test described in the previous section B.1.d Testing the Arduino.

B.2.b SD Card

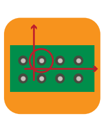
In this section, we will connect the SD card device to the Arduino using a standard Serial Interface connection. We will then insert an SD card, write some text into a file on that SD card, and finally insert the SD card into a computer card reader so that we can view the text file on the computer.



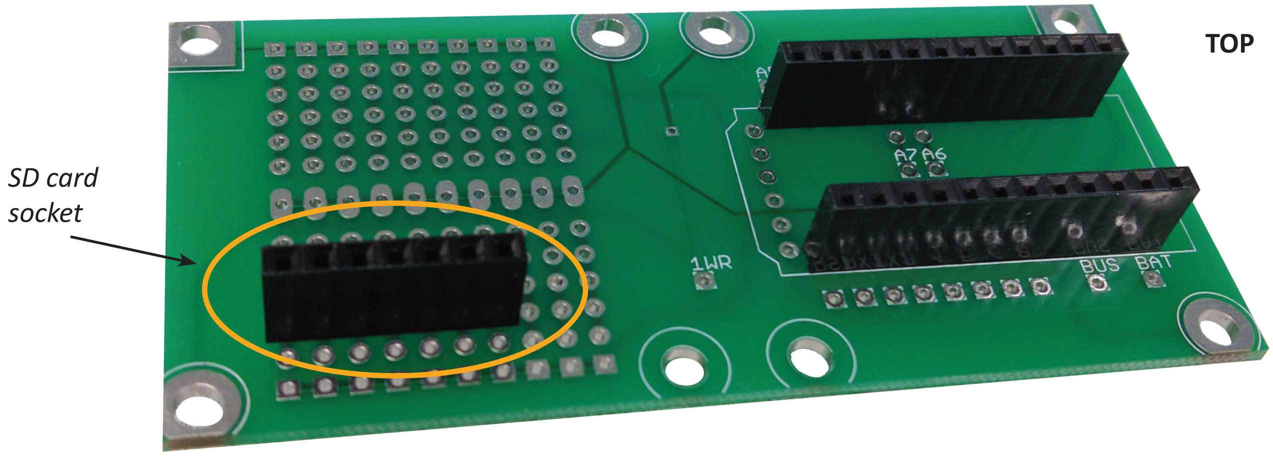
As shown in the figure, the wired connections are:

Color	SD Card pin	Connects to
Red	Vcc (Power)	Power Rail
Black	GND (Ground)	Ground Rail
Blue	DO (Data Out)	12
Orange on schematics	CS (Chip Select)	10
Yellow	SCK (Shared Clock)	13
Green	DI (Data In)	11

Note: Orange wire will be included in your kit. Some images may include white wires. White wires are equivalent to orange wires in the schematic.

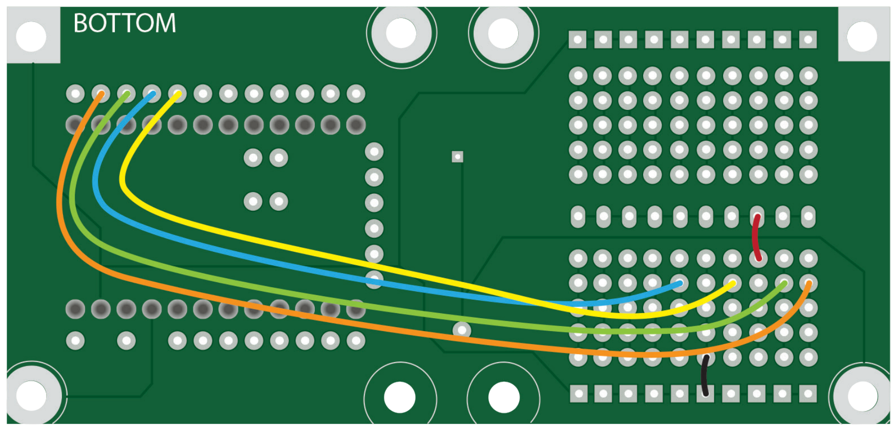


Place Socket
Insert the 7-pin socket into the protoboard as shown. Note the placement from the edge. The outside row is the power rail, then skip a row, then place the socket. Also note that the socket goes into the top of the protoboard.



Place Wires

The wires are placed on the bottom side of the protoboard, including the red and black jumpers for power and ground.



Check

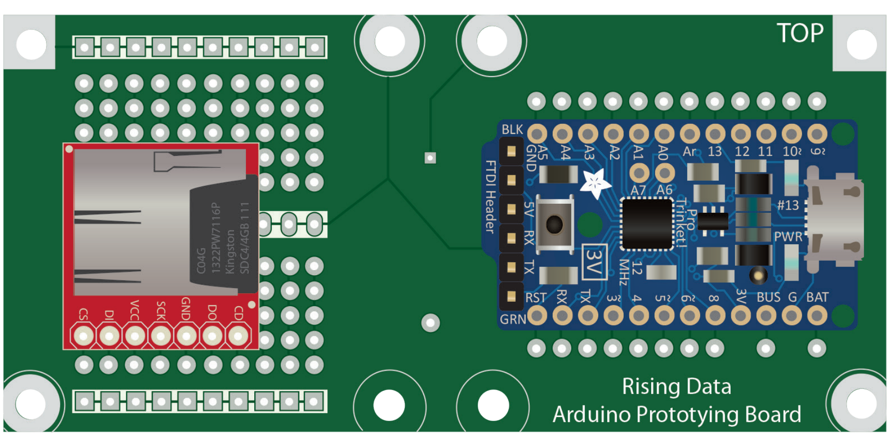
Have a partner check your work.

Solder

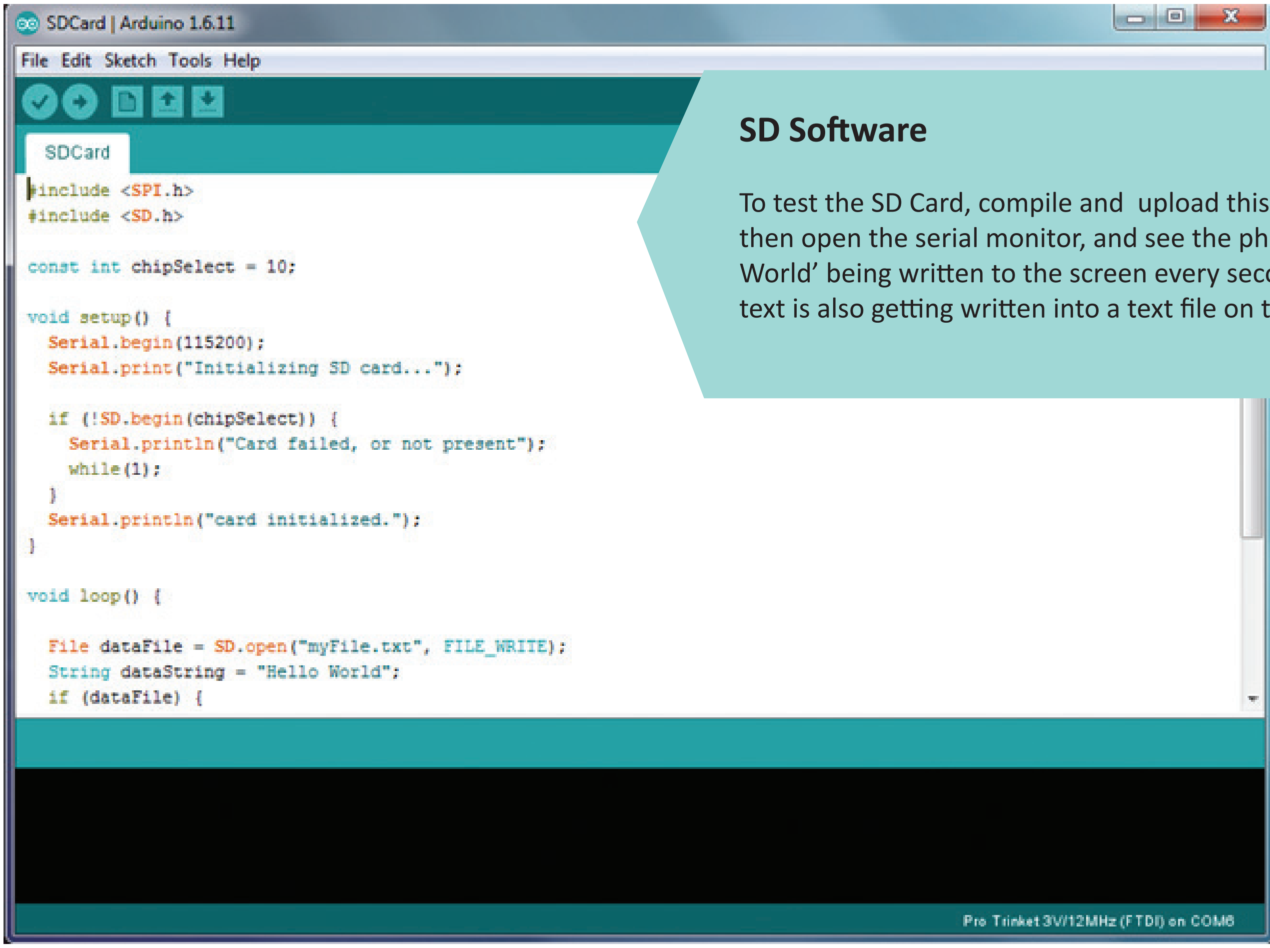
If your partner agrees that you have placed the wires and the socket correctly, you can solder these parts in place.

Test Software

Plug the SD card reader into the socket on the top side of the board. Proceed to test the SD card.

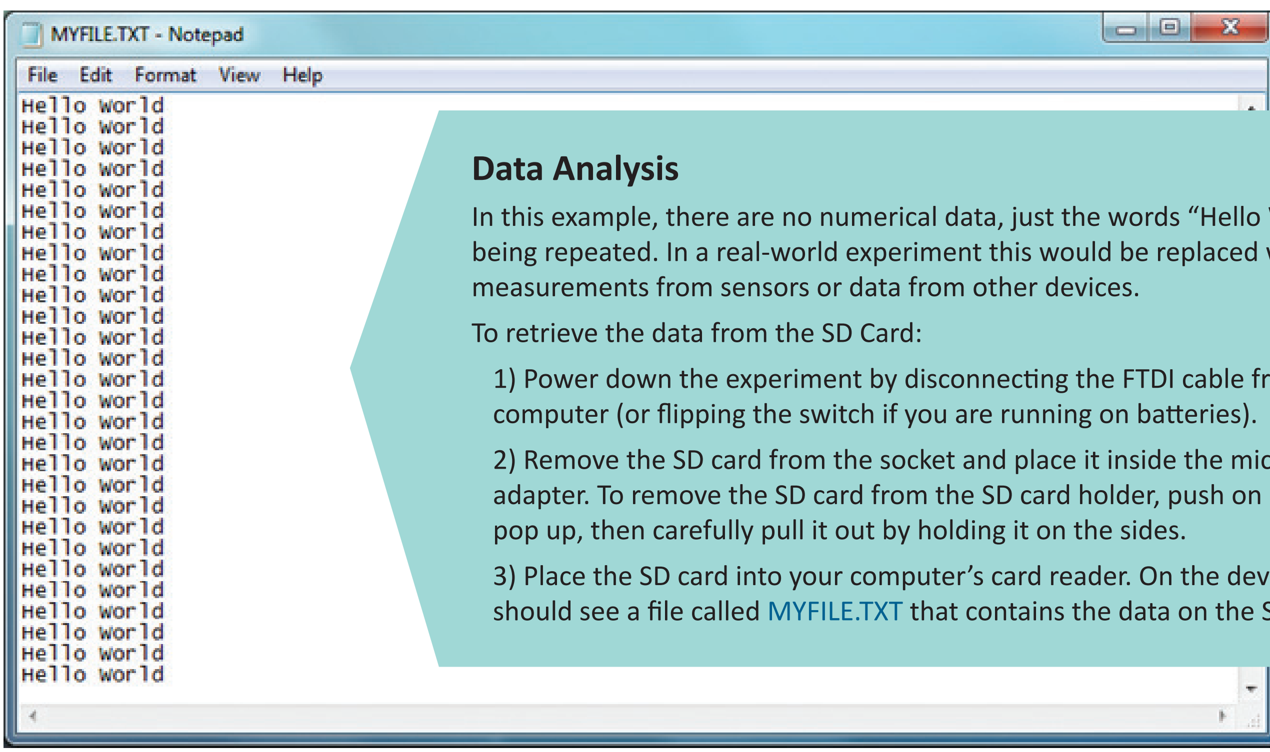


If the Arduino IDE is still open, you can find the SD Card software by using the File menu and choosing *Open Recent > SD Card*. Or *File > Open > lbym> N3_Source_Code > src > SDCard > SDCard.ino*



SD Software

To test the SD Card, compile and upload this sketch, then open the serial monitor, and see the phrase 'Hello World' being written to the screen every second. This text is also getting written into a text file on the SD card.



Data Analysis

In this example, there are no numerical data, just the words "Hello World" being repeated. In a real-world experiment this would be replaced with measurements from sensors or data from other devices.

To retrieve the data from the SD Card:

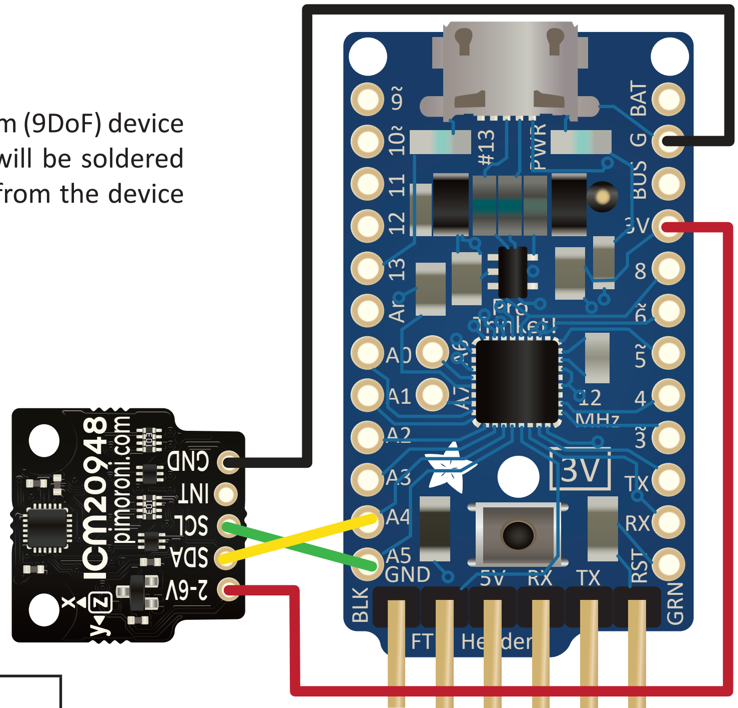
1) Power down the experiment by disconnecting the FTDI cable from your computer (or flipping the switch if you are running on batteries).

2) Remove the SD card from the socket and place it inside the microSD → SD adapter. To remove the SD card from the SD card holder, push on it and it will pop up, then carefully pull it out by holding it on the sides.

3) Place the SD card into your computer's card reader. On the device, you should see a file called MYFILE.TXT that contains the data on the SD card.

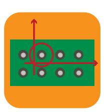
B.2.c 9DoF

In this section, we will connect the 9 Degrees of Freedom (9DoF) device to the Arduino using a socket and four wires, which will be soldered onto the protoboard. We will then read some values from the device and write them onto the SD card.



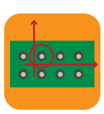
As shown in the figure, the wired connections are:

Color	9DoF pin	Connects to
Red	VDD (Power)	Power Rail
Black	GND (Ground)	Ground Rail
Yellow	SDA (Serial Data)	A4
Green	SCL (Serial Clock)	A5



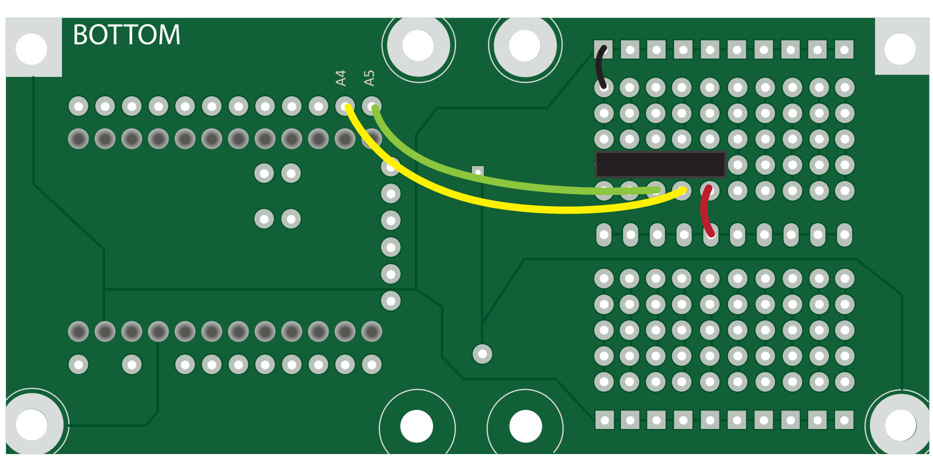
Place Socket

Insert the 4-pin socket into the bottom of the protoboard as shown. Note the placement from the edge. The outside row is the power rail, then skip a row, then place the socket. Also note that the socket goes into the bottom of the protoboard.



Place Wires

Attach power and ground jumpers to the rails and the yellow and green wires that connect the 9DoF to the Arduino. Note: Both the wires and the socket for the 9DoF get soldered onto the BOTTOM of the board. In the illustration below, the SD card wires have been omitted for simplicity.



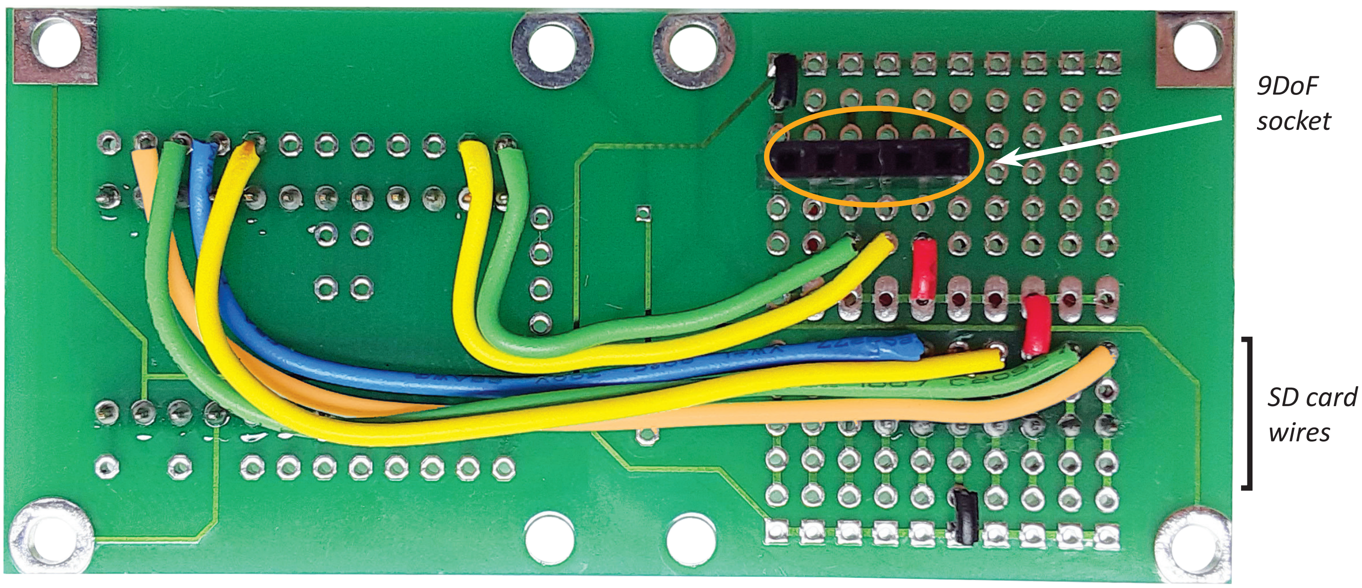
Check

Have a partner check your work.

Solder

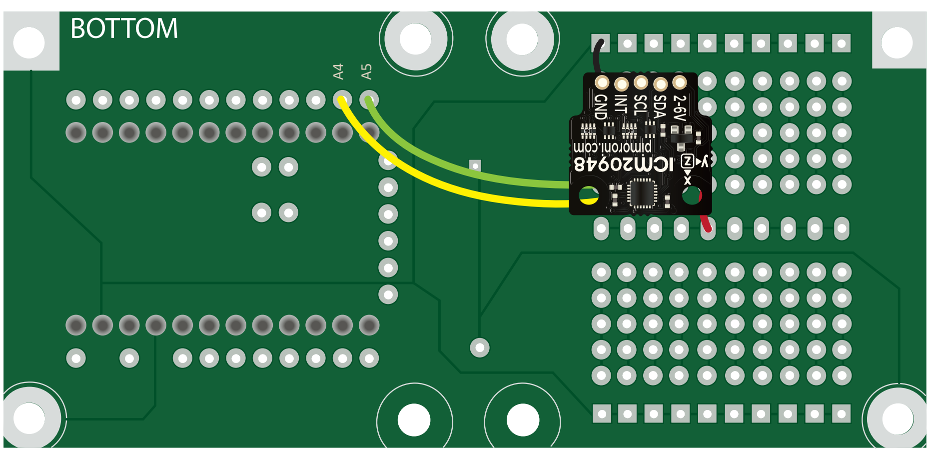
If your partner agrees that you have placed the wires and the socket correctly, you can solder these parts in place. When you are done, the bottom of the board should look like this:

BOTTOM



Test Software

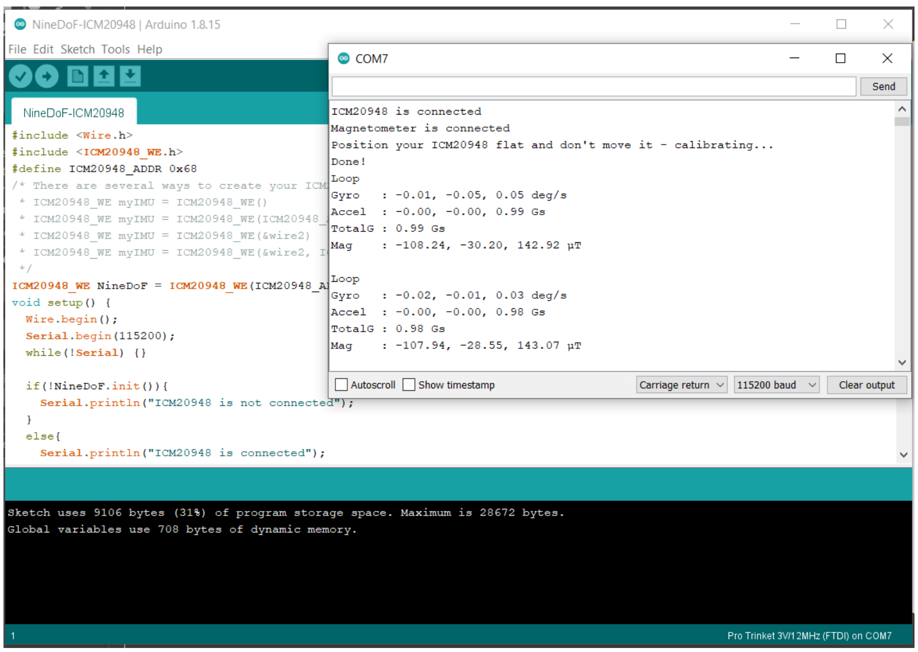
Plug in the 9DoF into the socket and proceed to the software test.



Once the 9DoF is plugged into the board, open the 9DoF sketch using the Arduino IDE. Select the File menu then *Open > lbym > N3_Source_Code > src > NineDoF-ICM20948 > NineDoF-ICM20948.ino*
You can compile and upload the sketch as written and then open the serial monitor to see the output of the 9DoF device. Feel free to move the device around and see what effect that has on the sensor readings.

The procedure for calibrating the sensor is as follows:

1. If the code has not been uploaded into the Arduino, execute an upload by clicking Upload button.
2. Before executing any code, place the sensor assembly motionless on a flat surface such as a table.
3. Open the console window by pressing the Serial Monitor button.
4. While watching the output, make sure that the ICM20948 and magnetometer are connected.
   - If not, close the console window and unplug the USB FTDI cable from the computer.
   - Wait about 10 seconds.
   - Plug the FTDI cable back into the USB port on the computer
   - Open the console window by pressing the Serial Monitor button.
5. Continue watching the console window looking for the completion of sensor calibration. This is indicated by the “Done!” print line in the console window.
6. Sensor calibration is now complete. You can move the sensor around noting changes in the data printed out in the console window.



- The screenshot shows the result of the calibration process.
- The data values for each of the 9 degrees of freedom are read out.
- The gyroscope measures the rotation around each axis in degrees per second.
- The accelerometer measures the acceleration (or gravitational force) in each direction in units of G. When the sensor is calibrated, it should return a value of 1 G in the z-axis direction.
- The magnetometer measures the strength of the magnetic field in each direction in microTeslas. The field at the surface of the Earth’s equator is approximately 30 microTeslas, increasing to twice that value at the poles.

Reality Check:

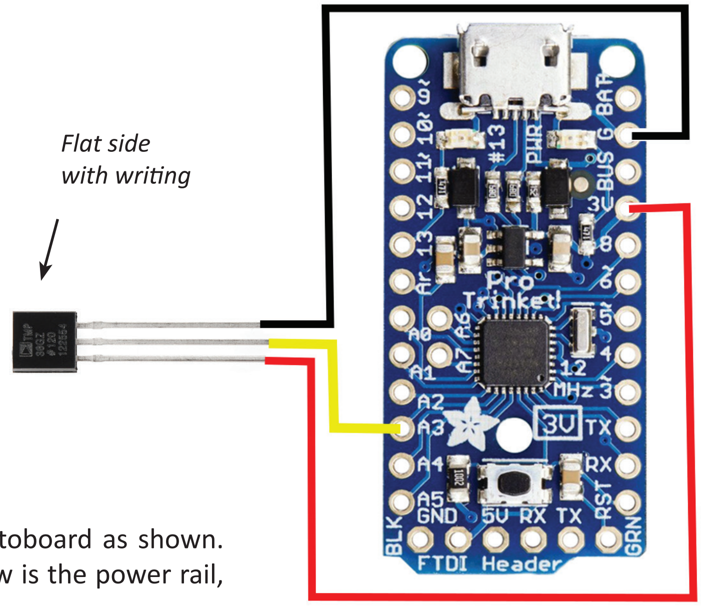
As you move the board around, the 9DoF values will change. Do they make sense? It may be easiest to look at the accelerometer values to decide.

B.2.d TMP-36

In this section we will connect the TMP-36 analog temperature sensor to the Arduino using a socket and one new wire, which will both be soldered onto the BOTTOM of the protoboard.. We will then read some values from the device and write them to the SD card.

The TMP-36 has three pins: power, data and ground.
The wired connections are:

Color	TMP-36 Pin	Connects to
Red	Power	Power Rail
Black	Ground	Ground Rail
Yellow	Data	A3

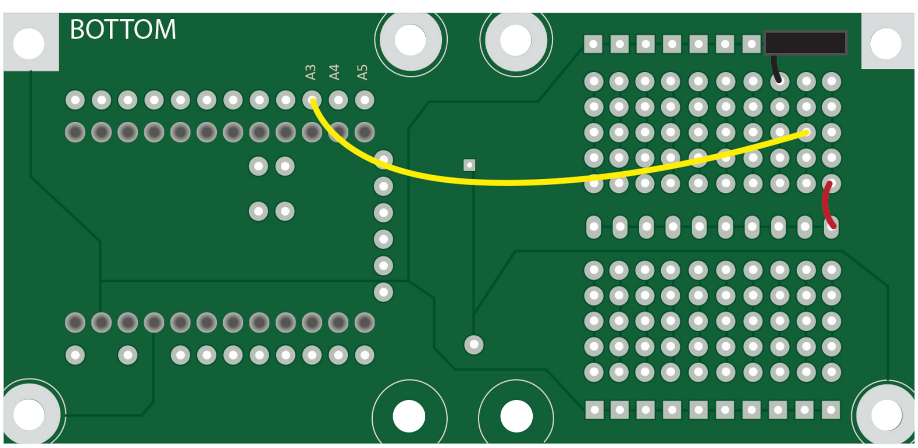


Place Sockets

Insert the 3-pin socket into the bottom of the protoboard as shown. Note the placement from the edge. The outside row is the power rail, then skip a row and place the socket.

Place Wires

Attach power and ground jumpers to the rails and the yellow wire from the data pin of the TMP-36 to the Arduino. Both the wires and the socket for the TMP-36 get soldered onto the BOTTOM of the board. In the illustration below, the 9DoF and SD card wires have been omitted for simplicity.

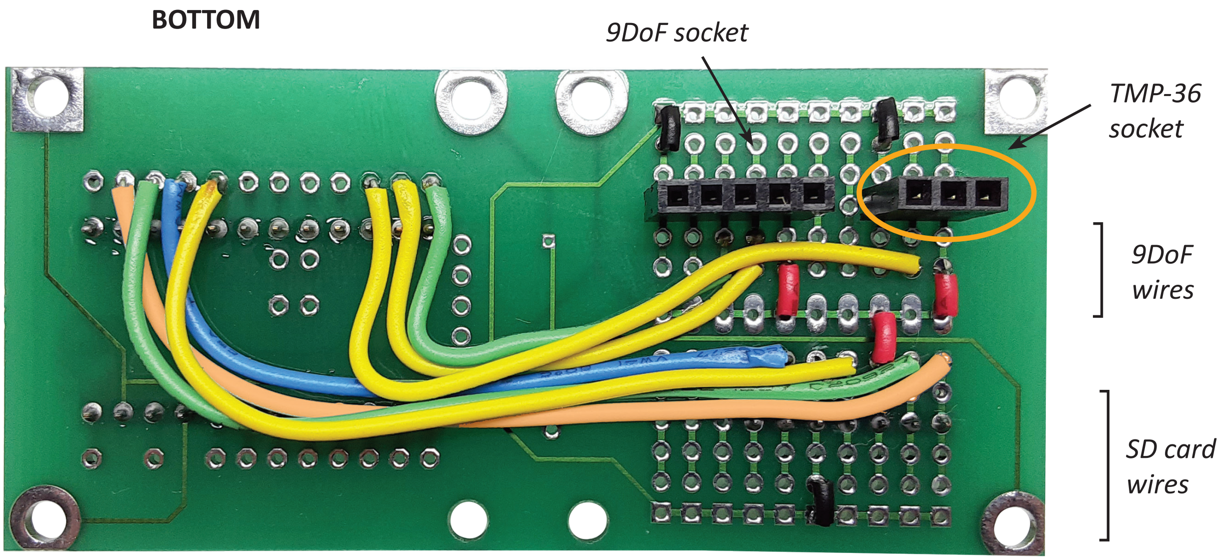


Check

Have a partner check your work.

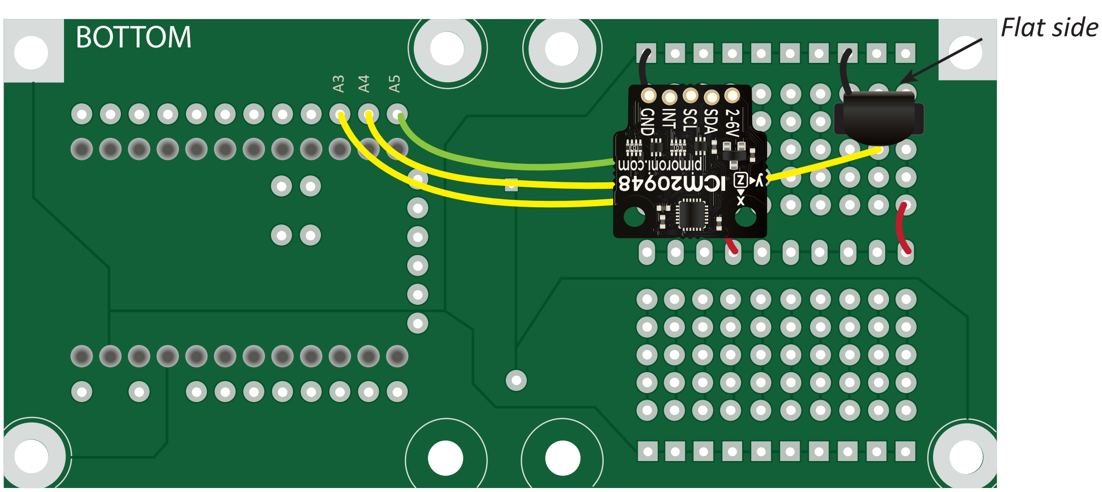
Solder

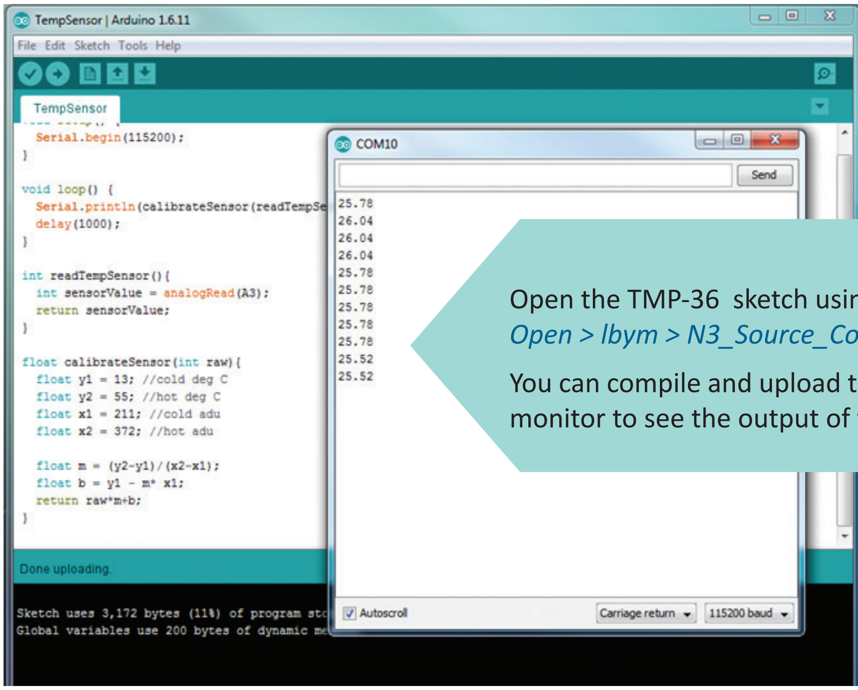
If your partner agrees that you have placed the wires and the socket correctly, you can solder these parts in place. The board should look like this when you are done.



Test Software

Plug the TMP-36 into the socket and proceed to the software test. Be careful to plug the temperature sensor into the socket so that the flat side with the writing on it is facing out. If you plug it in backwards, it will rapidly heat up and destroy the sensor.





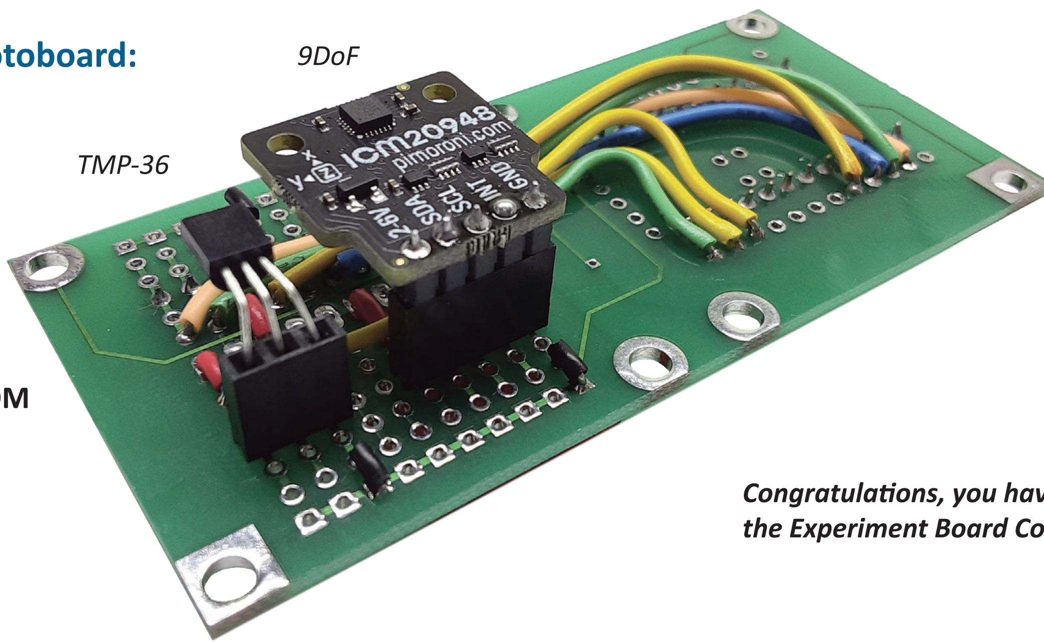
Open the TMP-36 sketch using the Arduino IDE. Select the File menu then *Open > lbym > N3_Source_Code > src > TempSensor > TempSensor.ino*

You can compile and upload the sketch as written and then open the serial monitor to see the output of the TMP-36 device.

Completed Protoboard:

9DoF

TMP-36

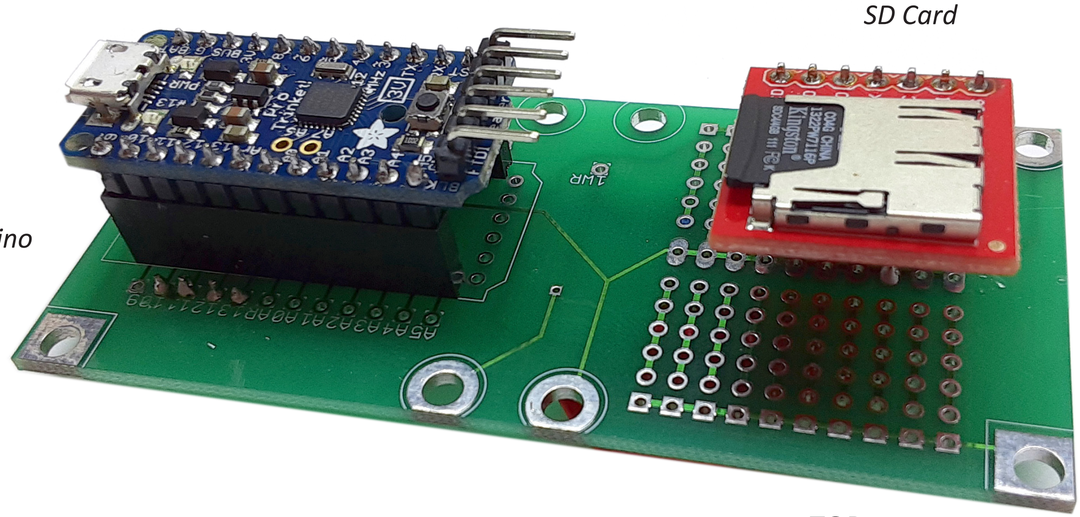


BOTTOM

Congratulations, you have completed the Experiment Board Construction!

SD Card

Arduino



TOP

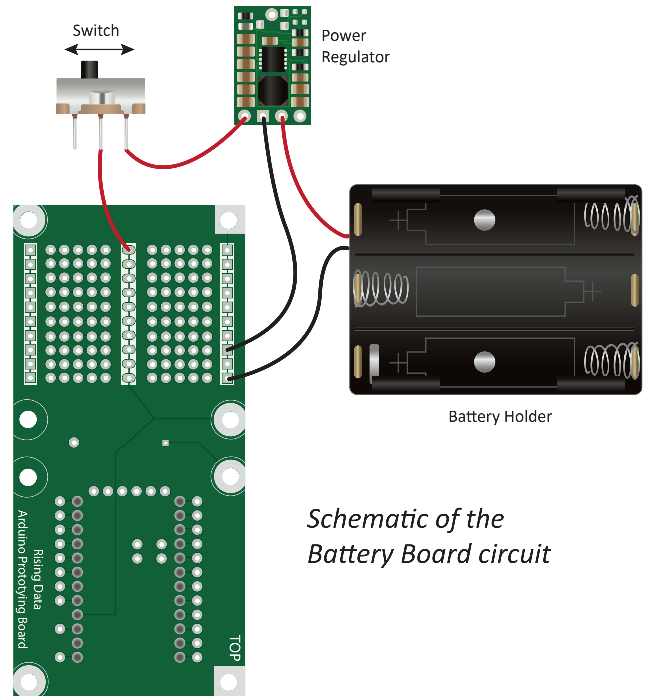
B.3 Battery Board

In this section we will solder the components onto another protoboard to create the Battery board. The Battery board delivers power to the Experiment Board that you have already completed. We will then use a digital multimeter to test that we can switch on and off a 3.3V power source. The battery board does not need any additional software.

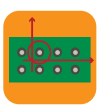
Note that we are using another green protoboard that is identical to the one that was used to build the Experiment Board. However, we will not be doing as much soldering to build this board.

B.3.a Regulator and Switch

If you follow the path of the power lines, in the schematic drawing to the right, you should see that power comes out of the battery and goes into the V_{in} pin on the power regulator. The power regulator ensures that the output pin always gives us exactly 3.3V. The output of the regulator goes through a manual switch that can be used to turn on or off the power to the Experiment Board. Note that the switch has 3 pins; moving the switch from side to side controls which two pins are electrically connected.

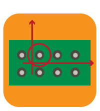


Schematic of the Battery Board circuit



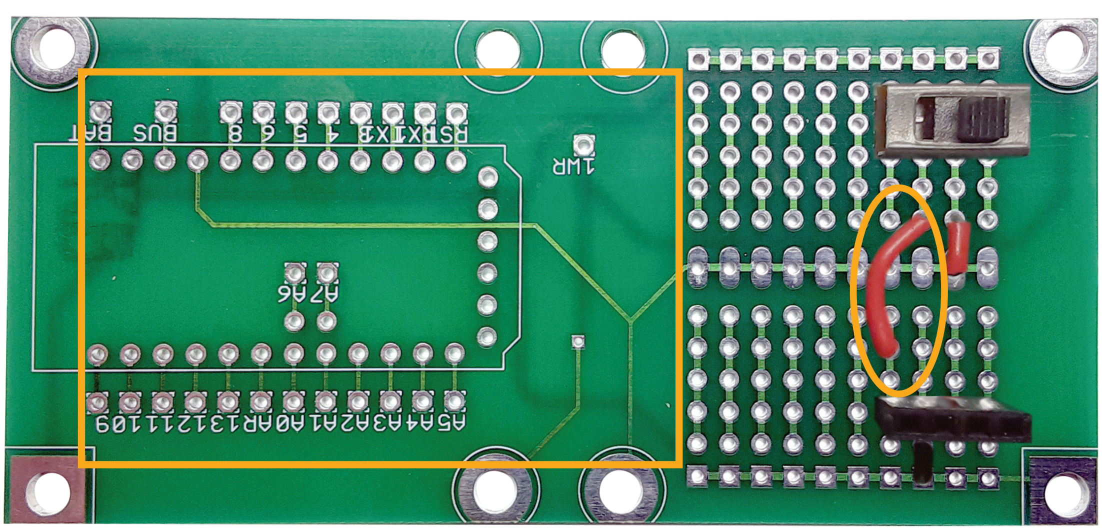
Place Regulator, Power Switch, and Solder

Place the four-pin header and power switch onto the TOP of the board. Note the alignment Solder these components in place. Make sure that no wires are sticking into the area that is shown as the red rectangle in the photo. This is the area that will hold the battery pack.
The photograph below also shows the power, ground and regulator wires after soldering.



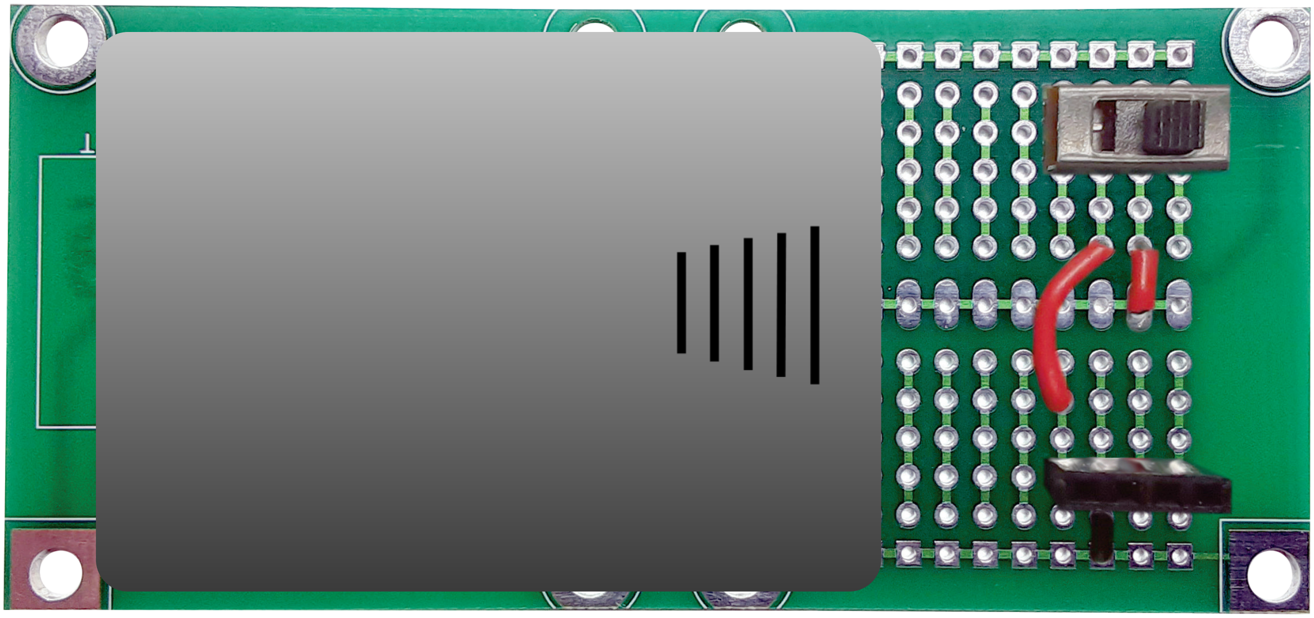
Place Wires

Strip and place wires on the top side of the board to connect the ground and power for the regulator.
Place wire connecting the output of the switch to the input of the regulator.



Battery compartment placement

Peel cover from sticky tape. Place battery compartment as indicated in the diagram below.
Cut and place the power and ground wires to the input on the switch and ground respectively. Sometimes it is helpful to place a piece of tape over the wires to hold them in place.



Double check the placement of the wires to ensure that they are attached to switch and power regulator correctly.

Check

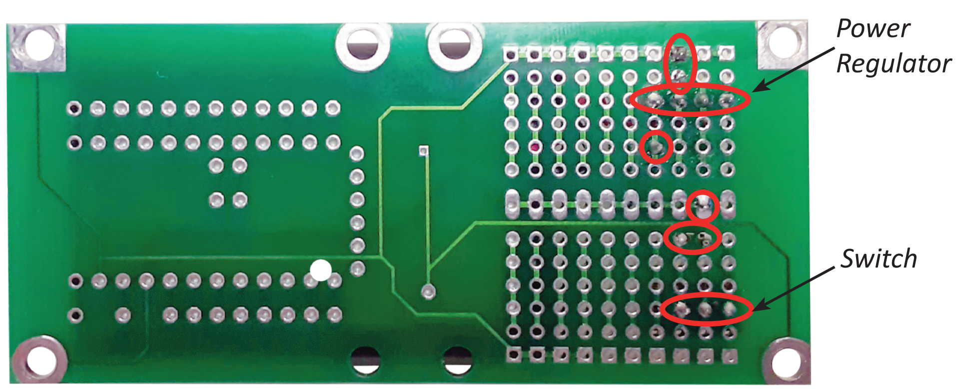
Have a partner check your work.

Solder Wires, Header, and Battery Holder

If your partner agrees that you have placed the wires correctly, you can solder these parts in place.

Clip extra leads after soldering.

This illustration shows the BOTTOM of the board after soldering. The circles show the places where there is solder for the parts and the wires.



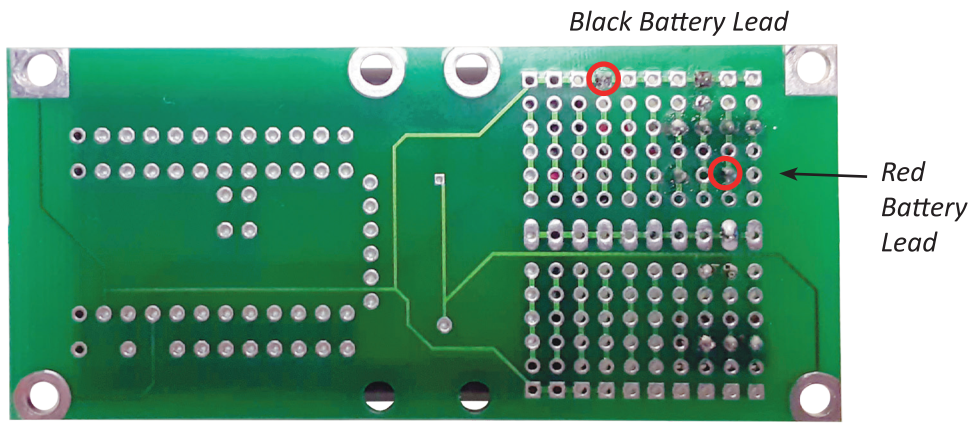
BOTTOM

Solder Battery Leads to the Board

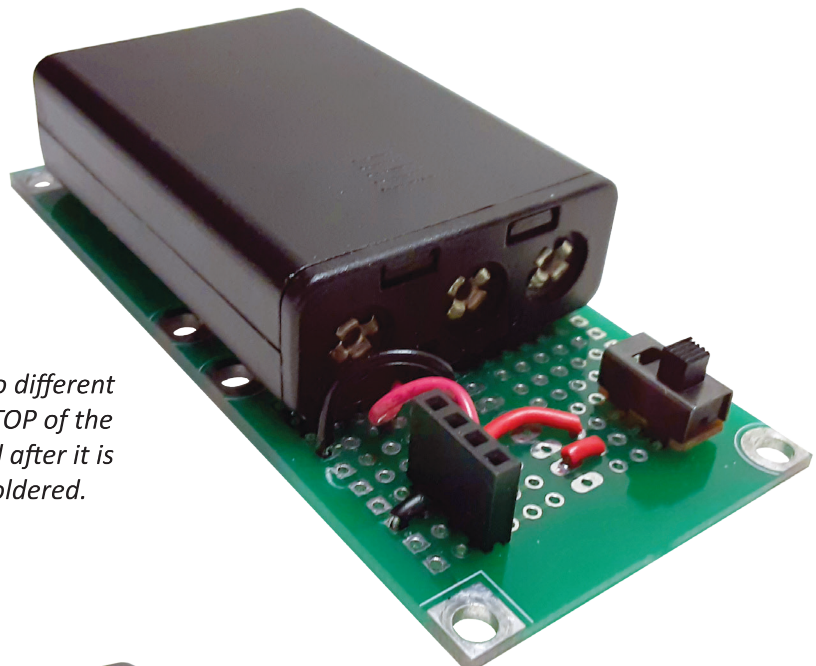
Cut and strip battery compartment leads. Since these leads are braided wire, you will have to "tin" the ends by coating them with solder, prior to sticking them through the holes and soldering them to the board. The black lead connects to the ground rail and the red connects to the rail connecting the Vin on the power regulator. Solder the leads in place.

Clip leads after soldering.

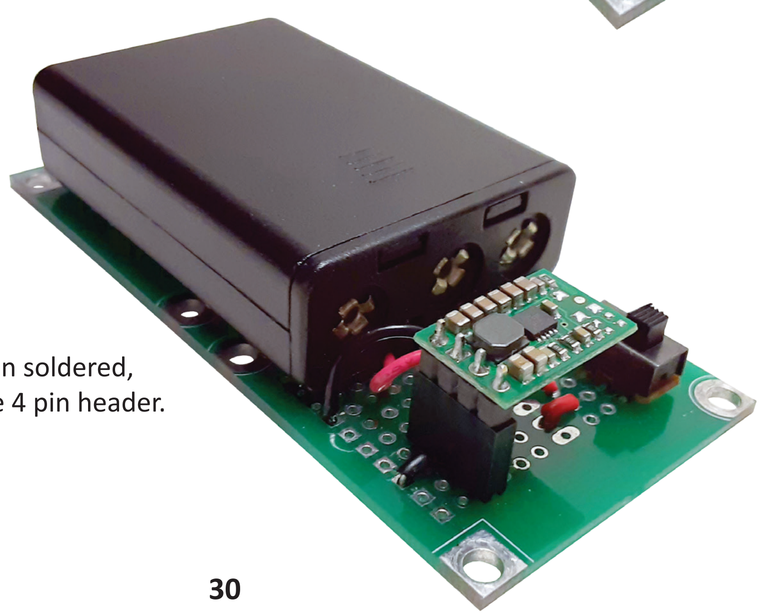
The illustration shows the BOTTOM of the board after soldering on the battery leads. The red circles show the positions of the new solder joints.



BOTTOM



These are two different views of the TOP of the battery board after it is done being soldered.

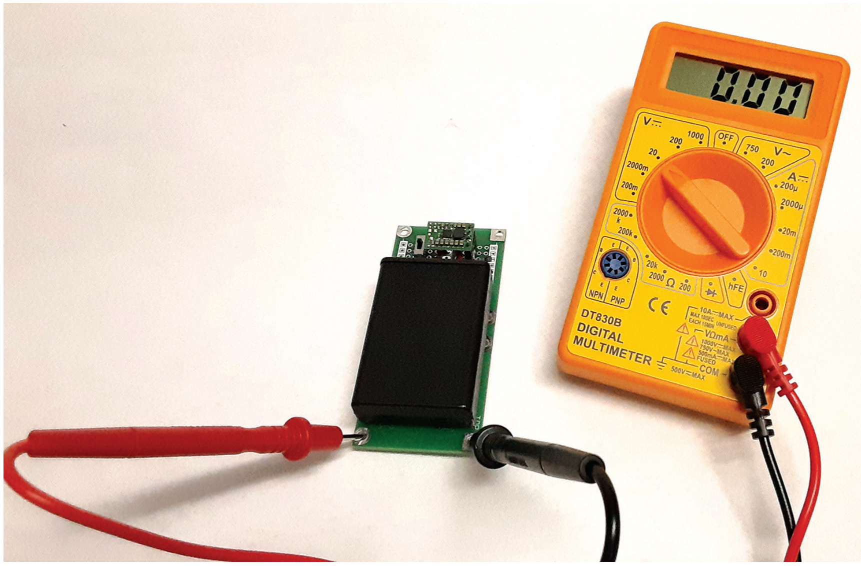


Once all components have been soldered, install power regulator into the 4 pin header.

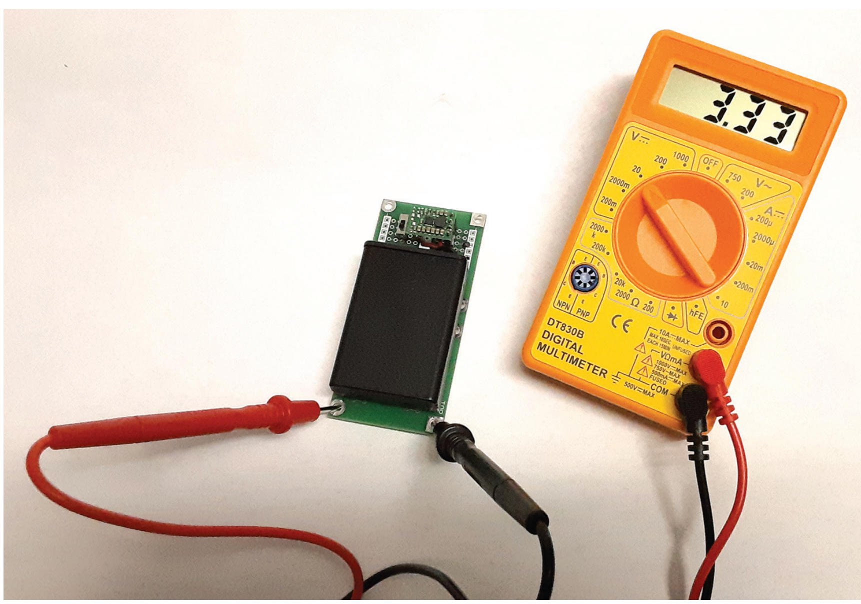
B.3.b Battery Test

Insert three AA batteries into the battery holder. This board should provide a 3.3v source to the power and ground rails when switched on, and no voltage when switched off.

Test 1: With the device in the **off** position (switch towards the battery cradle) place the probes of your multi-meter through the power and ground rail holes. You should get a value very close to zero. Some volt meters may report voltage in the millivolt range. This is OK.

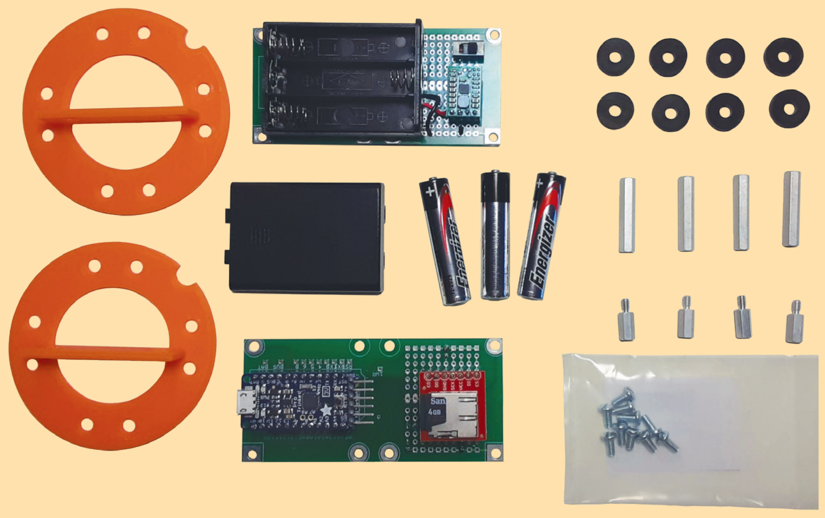


Test 2: Switch the device to the **on** position (away from the battery cradle) and you should see the voltage jump up to around 3.3V.



Congratulations, you have completed the Battery Board construction!
You now have a system that will deliver power to the Experiment Board.

C. Assembling the Payload System

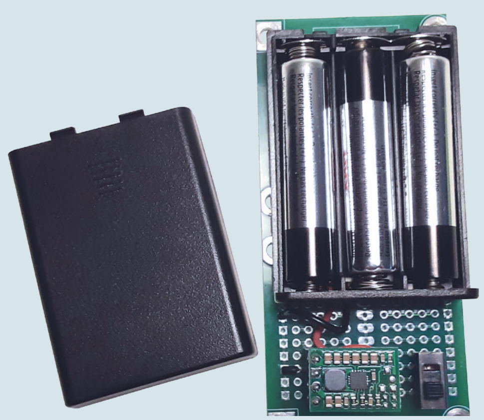


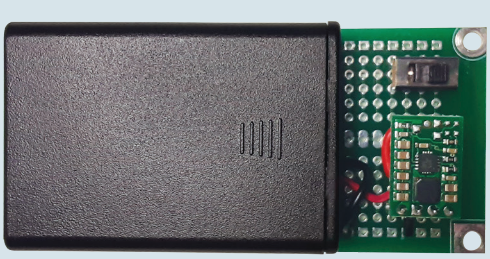
Material Needed:

- Two 3D printed Sleds
- Battery Board with 3 AAA Batteries
- Payload Board
- Eight Rubber Washers
- Four 1” Hex Standoffs
- Four 3/8” Hex Standoffs
- Eight Slotted Screws

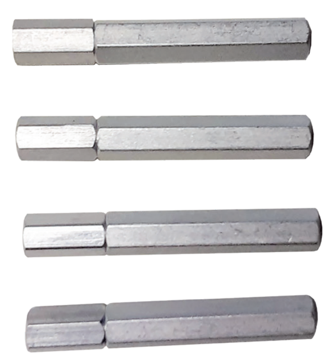
Assembling the Payload

1. If batteries have not been inserted into the battery compartment, make sure the switch on the battery board is set to off and insert 3 batteries into compartment in the correct orientation indicated in the compartment. Replace the cover closing the battery compartment.

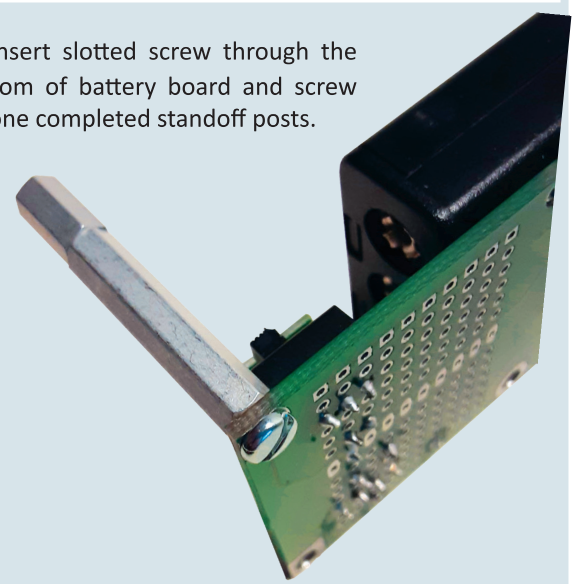




2. Using the 4 x 3/8” standoffs and 4 x 1” standoffs, connect one 3/8” standoff with one 1” standoff. Repeat this until 4 standoff posts have been created.



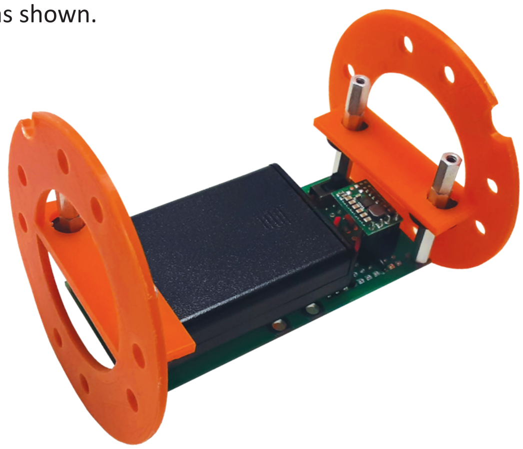
3. Insert slotted screw through the bottom of battery board and screw on one completed standoff posts.



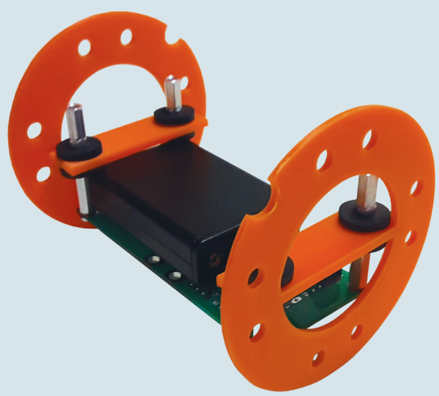
4. Repeat until all four corners are complete. Use slotted screwdriver to snug the screws so they are not loose. **DO NOT** over tighten.

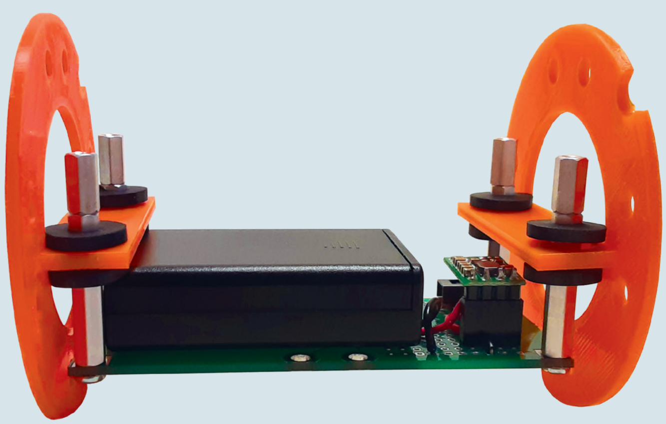
5. Carefully press on four rubber washers on each standoff post. Press down until the washer is about ½ down the post

6. Place 3D printed sled over the standoff posts as shown.

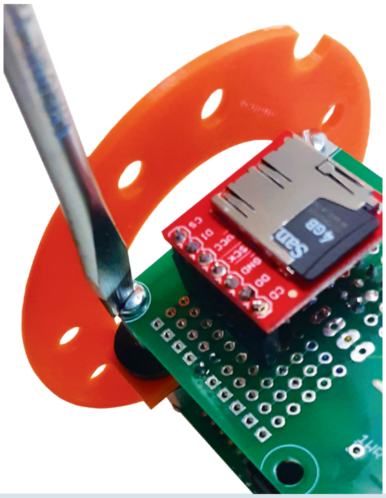


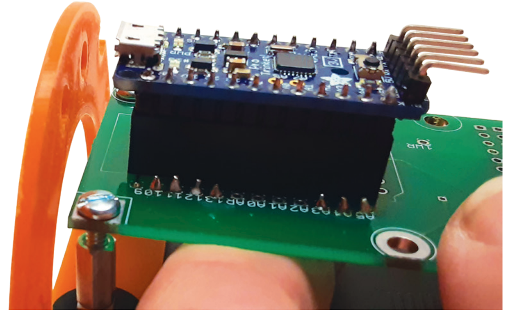
7. Carefully press on four remaining rubber washers on each standoff post until they are snug against the sled parts.

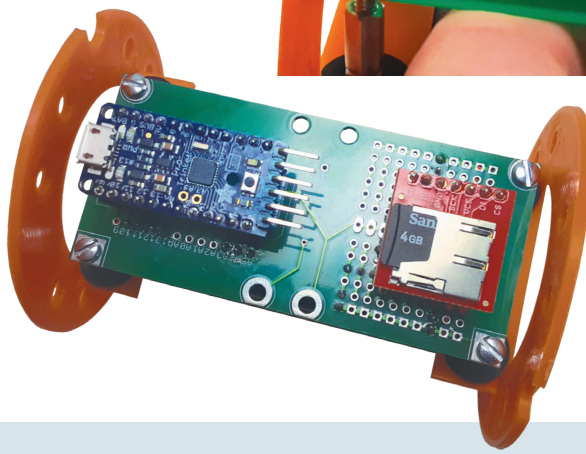




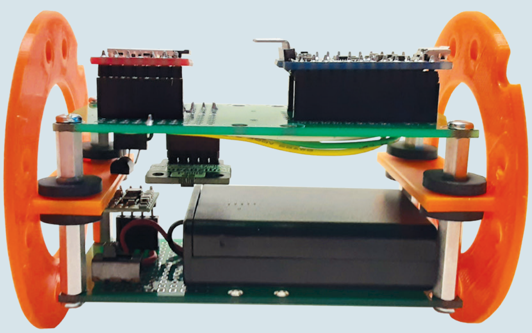
8. Insert slotted screw through a corner of the top of the payload board. Use the slotted screw driver to start into the standoff post. Repeat until all four sides are complete. Snug the screws so they are not loose. **DO NOT** over tighten.

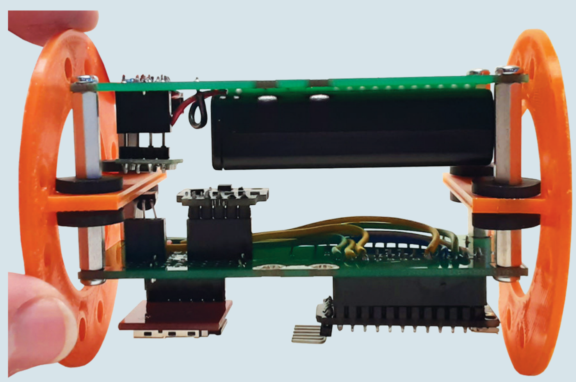




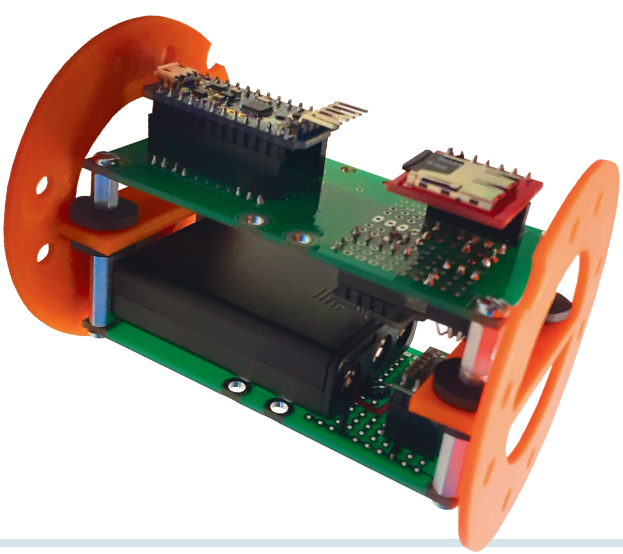


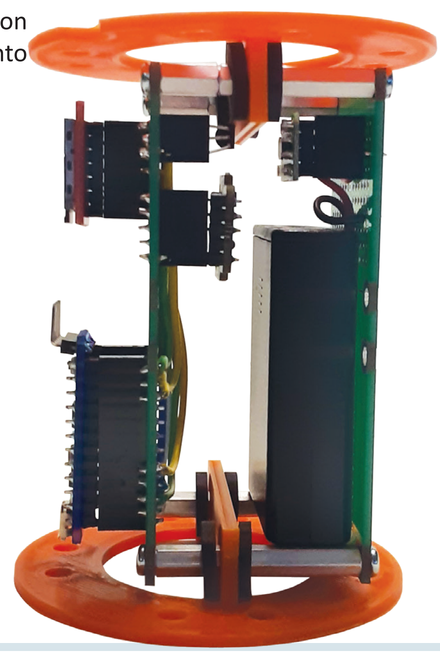
9. If necessary slide the payload on the rails until there is adequate clearance above the payload board and below the battery board.





10. The payload assembly should now be complete. Take note of the orientation of the payload in the image below. This is how the payload should be loaded into the rocket. The 9DoF sensor's positive Y direction is pointing up.

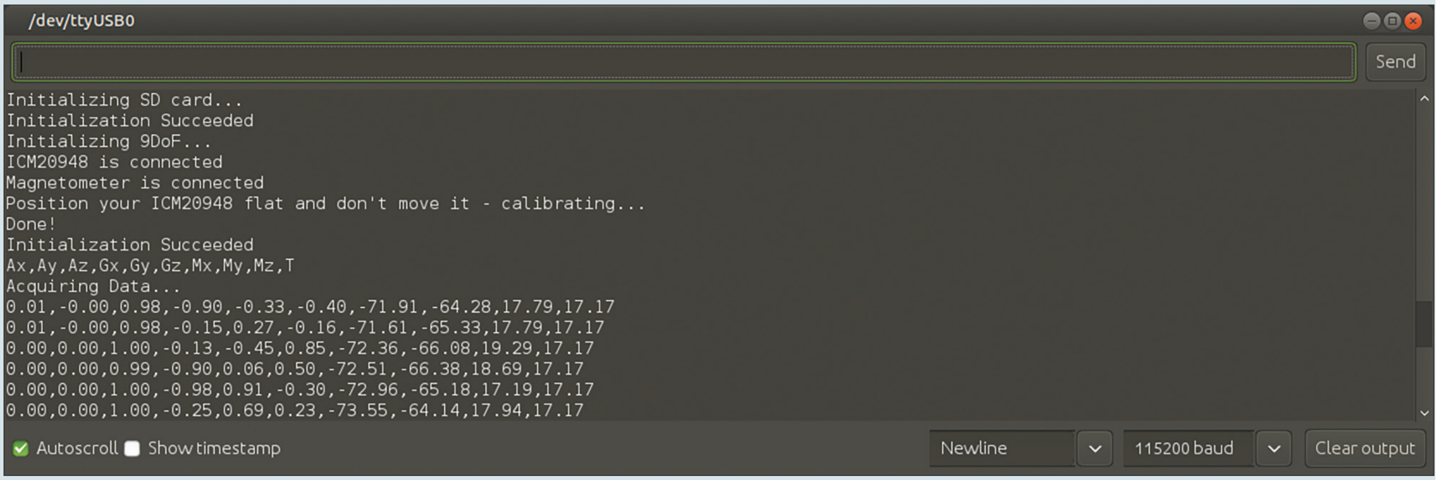




11. Load the payload software

Connect the FTDI cable to the Arduino as before and start up the IDE on the computer.

Select the File menu then *Open > lbym > N3_Source_Code > src > RisingData-ICM20948 > RisingData-ICM20948.ino* You can compile and upload the sketch as written and then open the serial monitor to see the output. Make sure to place the payload on a table so that the Arduino/battery pack are at the bottom for proper calibration.. The output should look like this:



- The screenshot shows the result of the calibration process.
- The data values for each of the 9 degrees of freedom are read out along with the temperature value: Ax, Ay, Az, Gx, Gy, Gz, Mx, My, Mz, T.
- The accelerometer measures the acceleration (or gravitational force) in each direction in units of G (Ax, Ay, Az). When the sensor is calibrated, it should return a value of 1 G in the z-axis direction.
- The gyroscope measures the rotation around each axis in degrees per second (Gx, Gy, Gz).
- The magnetometer measures the strength of the magnetic field in each direction in microTeslas (Mx, My, Mz). The field at the surface of the Earth's equator is approximately 30 microTeslas, increasing to twice that value at the poles.
- The final number is the temperature in degrees Celsius (T).
- SD card from the board, putting it into your computer's card slot (using the adapter if needed) and copying the data onto your computer.
- The 9DoF data are written into a spreadsheet file called DATALOG.CSV

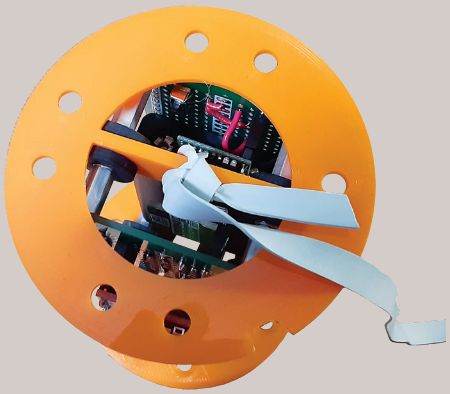
Congratulations, you have completed the Assembly of the Payload System! You now have all the parts you need to assemble the rocket and integrate the payload into the rocket.

D. Rocket Assembly & Payload Integration

The payload and parachute are loaded into the rocket as a unit. After launch, the rocket comes down with the streamer, and separately, the payload comes down with the parachute.
For a step by step, see the video by Tony Alcocer, starting at 19:44.

https://www.youtube.com/watch?v=A4yP8UF8F94

1. Cut the rubber shock cord in half. Attach one end to the cross bar on the 3D printed end of the payload "sled".



2. Find the centers of the parachute's shroud lines. Tie them into a loop as a group. Tie the remaining end of the rubber shock cord to the loop you just formed.

3. Folding the streamer.
First stretch it out flat.

Then fold it in half five times:

Fold # 1

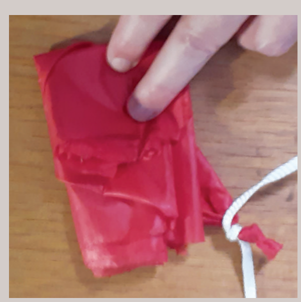
Fold # 2

Fold # 3

Fold # 4

Fold # 5

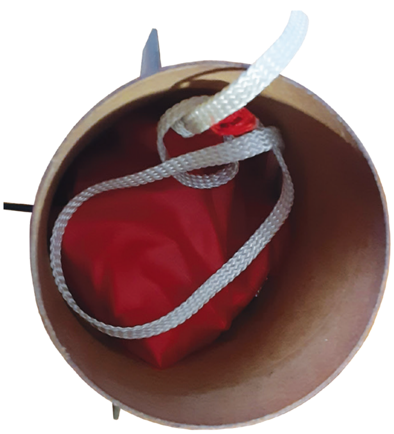
Then fold it in thirds along the longer side of the streamer.



Put something heavy on it so it stays folded and set it aside.

4. Fluff up the scrubbing pad then push it down into the main tube on top of the engine mount tube. The purpose of the scrubbing pad is to protect the streamer and payload from the heat of the motor.

5. Next, insert the folded streamer into the main body tube on top of the scrubbing pad.



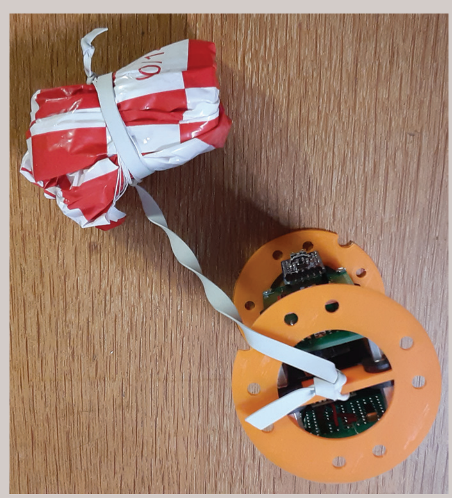
6. Folding the parachute:

a. Take the parachute and stretch it out

b. Fold it in half lengthwise

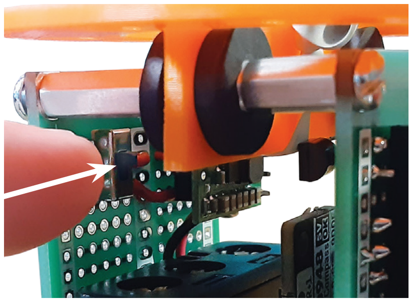
c. Fold it in half again

d. Wrap the parachute shroud lines and elastic cord around the parachute.

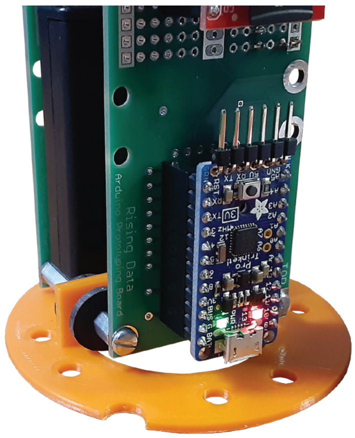


7. If you are at the launch site and are ready to launch your rocket, then turn on the payload and recalibrate it

a. Turn on the switch on the battery board



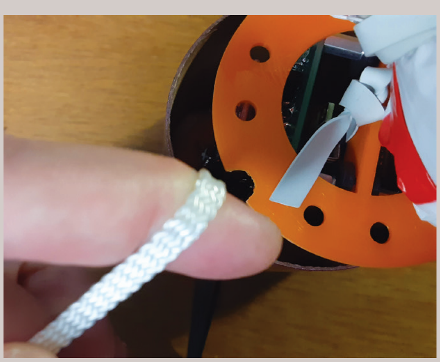
b. Place the payload so that the Arduino and battery pack are at the bottom



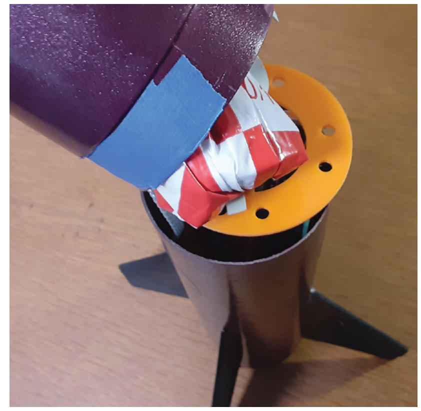
8. Insert the payload

a. The payload gets inserted into the main body tube with the Arduino/battery pack on the bottom.

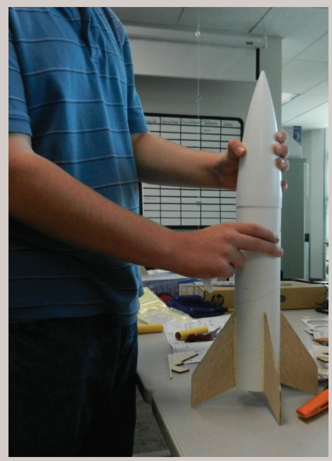
b. Make sure the long white shock cord is fed through the notch in the top sled



9. Place parachute and remaining shock cord on top of the payload in the main body tube.



10. Take any remaining white shock cord and place it into the nose cone. Then carefully join the nose cone with the rocket body.



11. Adjust nose cone fit by either additional sanding (if it is too tight) or adding masking tape on the lip of the nose cone that slides into the main body tube (if it is too loose). Note: these adjustments can also be done prior to launch.

Congratulations!
You have assembled your N3 rocket and integrated the payload!
You are now ready to launch.

Neurodiversity may be every bit as crucial for the human race as biodiversity is for life in general

Harvey Blume

N3.sonoma.edu