Acoustic Levitator

by UpnaLab

Use acoustic waves to hold in mid-air samples such as water, ants or tiny electric components. This technology has been previously restricted to a couple of research labs but now you can make it at your home.

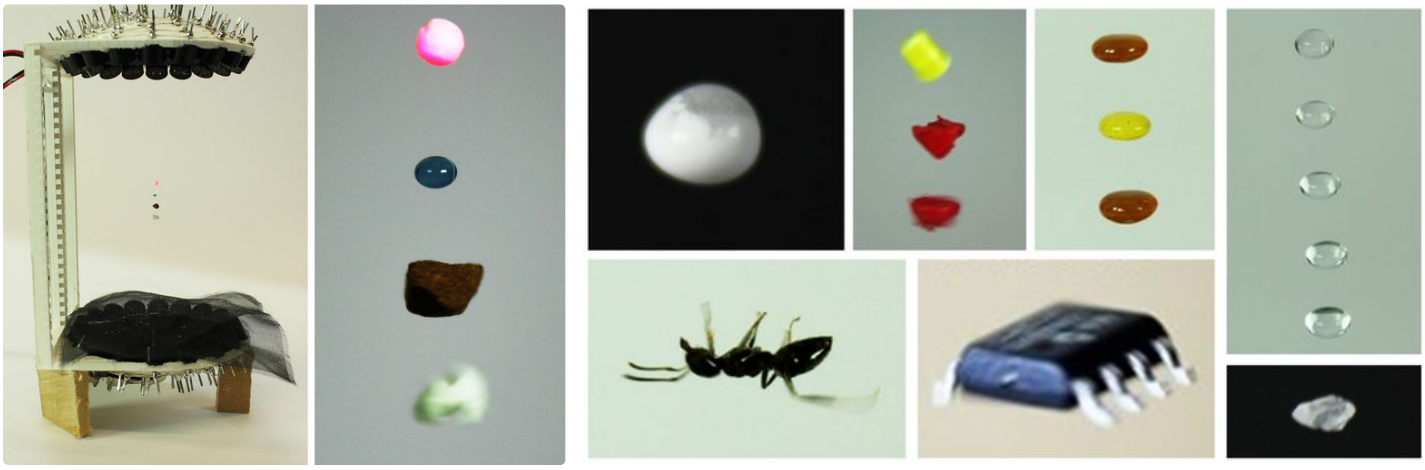
If you want more background and details you can check our **Open Access papers**:

- More details and supplementary information about this levitator
- How Acoustic Tractor Beams Work
- Acoustic Delay Lines for Compact Tractor beams

Do not forget to watch the attached video. The first video is the instructions whereas the second one is a fantastic video by Physics Girl **explaining the physics behind it.**

If you want to build other devices coming directly from the research lab subscribe or get in touch: Youtube: https://www.youtube.com/user/asiermarzo

Twitter: @AsierMarzo



https://youtu.be/yVDWrWpaBho

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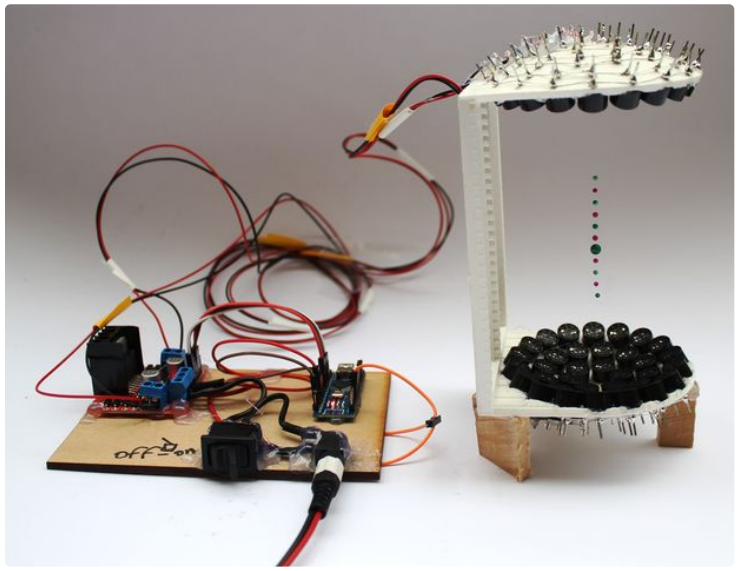


Step 1: Gather the Components

Kit

Now you can get all the components in this kit:

https://www.makerfabs.com/index.php?route=product/product&product_id=508

https://www.tindie.com/products/Makerfabs/acoustic-levitator-kit/

https://www.robotshop.com/de/de/acoustic-levitator-kit.html

Individual components

We present a list of the necessary components. I have tried to place links for different countries. However, the same parts can be found all around the world, some useful websites are http://www.findchips.com/ http://www.dx.com/ http://www.findchips.com/ http://www.lightinthebox.com/ http://www.findchips.com/

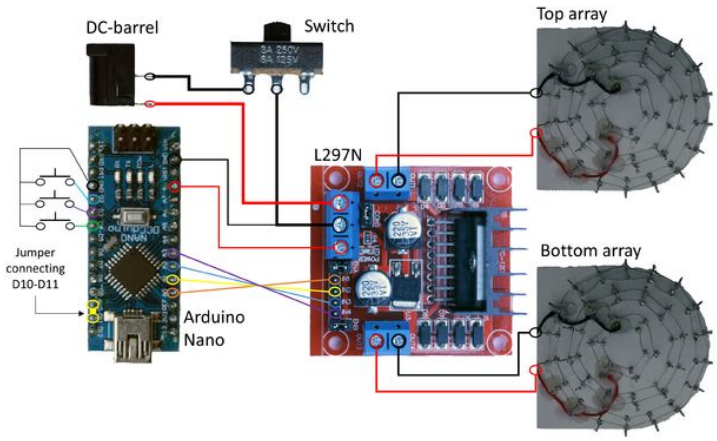
- 72x 10mm 40kHz transducers. Manorshi provides MSO-P1040H07T at a very good price, minimum order is 500 but they will ship with less at a higher price. Also Ningbo has good ones FBULS1007P-T
- 1x 3D-printed TinyLev support. (STL file provided in Step 2)

- 1x Arduino Nano (US UK)
- 1x L298N Dual Motor Drive Board (US UK)
- 1x 130x90mm sheet (wood or acrylic) for the base of the driver board.
- 1x power switch
- DC adaptor variable between 7V and 12V
- DC female connector
- Jumper wires

- 12AWG black and red wire
- 24AWG black and red wire
- 24AWG exposed wire (UKUSA)
- Some Expanded Polystyrene beads to levitate (between 1mm and 3mm diameter)
- An acoustically transparent material: A metallic grid, very thin fabric or teabag paper.
- If you plan to run your levitator for days or at at voltages above 12V you may want to upgrade the he atsink of the drivers. Thanks to johnfixesstuff for the Info.

Necessary Tools

- 3D printer -> you can use an online service
- Soldering Iron, Tin and Flux.
- Hot-glue gun
- Multimeter
- Cable Peeler
- Screwdriver and Pliers.
- Drill
- Oscilloscope with two probes (optional) -> you can get one for less than 50£ http://amzn.eu/5ey6ty2

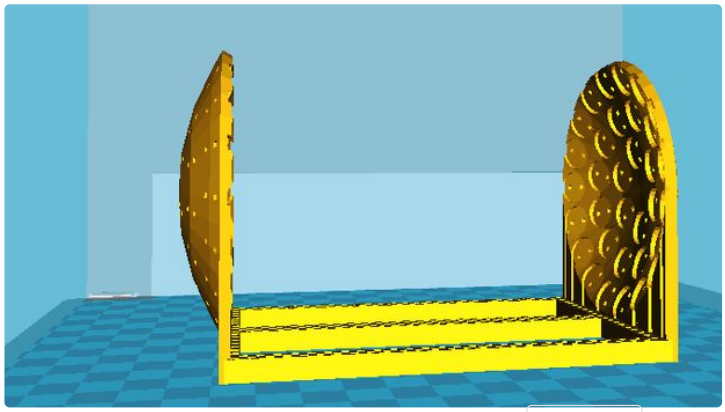


Step 2: 3D Print the Base

3D print the base for the levitator. We used a 0.4mm nozzle and brim but no support. It should be possible to print it in one piece. A 0.6mm nozzle also provides good results.

Included in this step, you have the first version (v0 14 x 7.86 x 8.31cm). Or you can use the next version with some reinforcement in the joints (v1 15.6 x 7.86 x 8.54cm).

- You may also want to print the fantastic stand from Jeff Bearer
- Or you can also use a full case to make more robust and look awesome. by Jakub_Nagy



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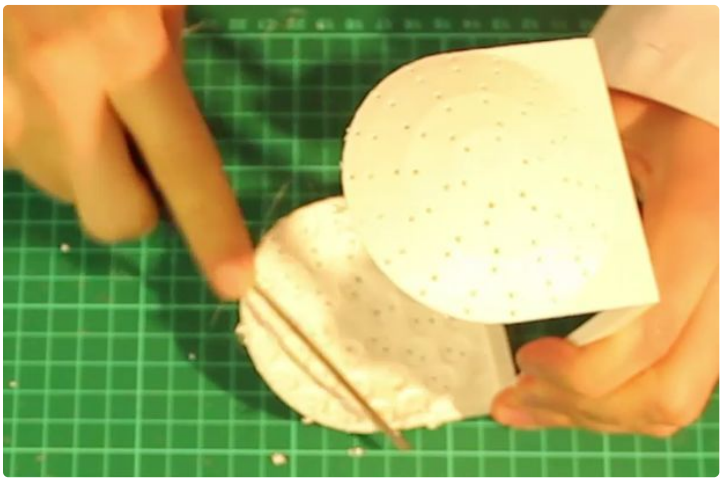
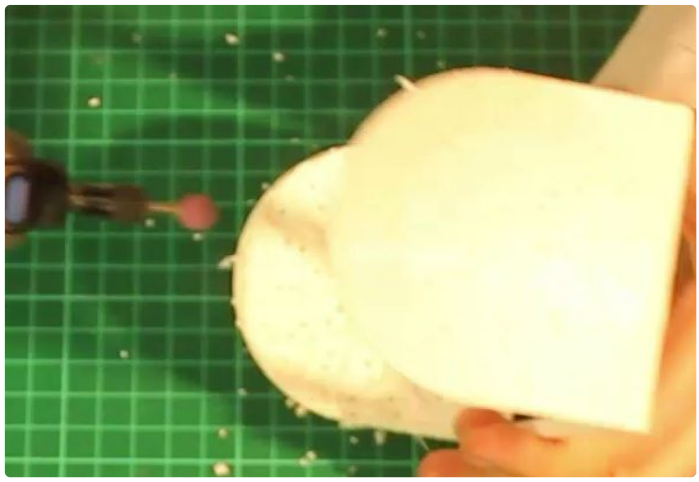
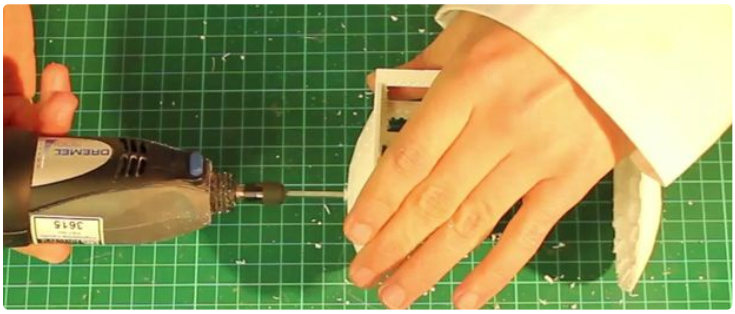
Step 3: Clean the Base

You may need to use a file to clean the edges around the levitator and clean the sockets. A Dremel will do the job faster. You may also want to drill a hole in the centre of each side, this will allow to insert a camera, a needle or evacuate liquids.







Step 4: Mark Polarity (using a Multimeter)

If you have a multimeter and some copper tape, this method is quite simple to perform.

DO NO TRUST THE POLARITY MARKINGS FROM THE MANUFACTURER!!!

https://www.youtube.com/watch?v=0HaKv3aJQWA

Step 5: Mark Polarity (Using an Arduino)

The easiest way to mark the polarity is to use the Arduino itself. This method does not require an oscilloscope or to poke the transducers inside.

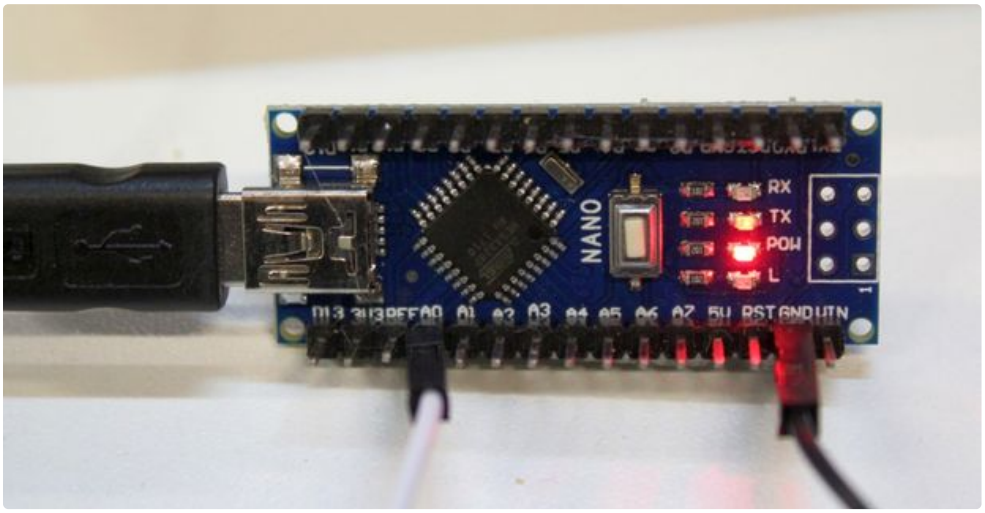
Install the code from this section into the Arduino. Connect one wire to A0 and another wire to GND.

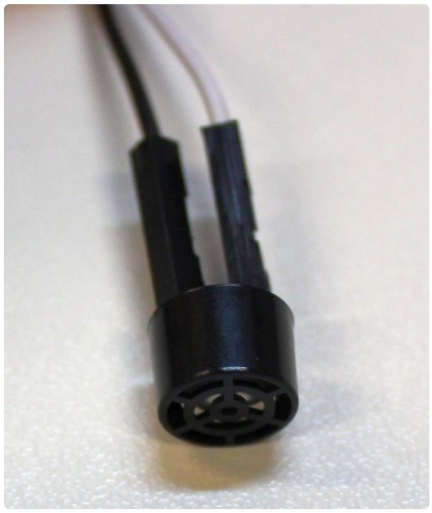
While the Arduino is connected to the PC, run the Serial Plotter (Tools->Serial Plotter) and be sure that the speed is set to 115200.

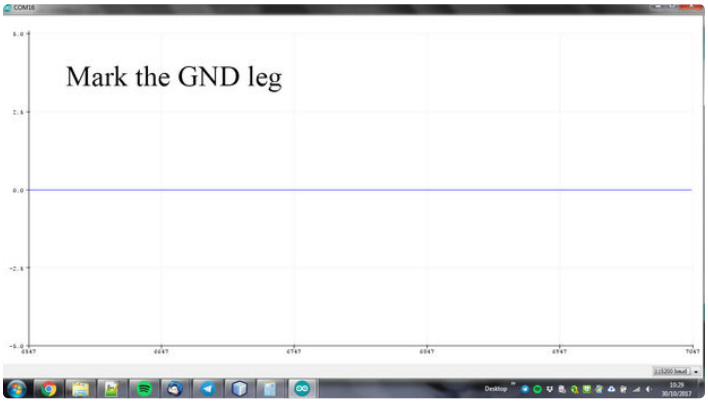
When a transducer is connected between A0 and GND the signal will do one of the following things:

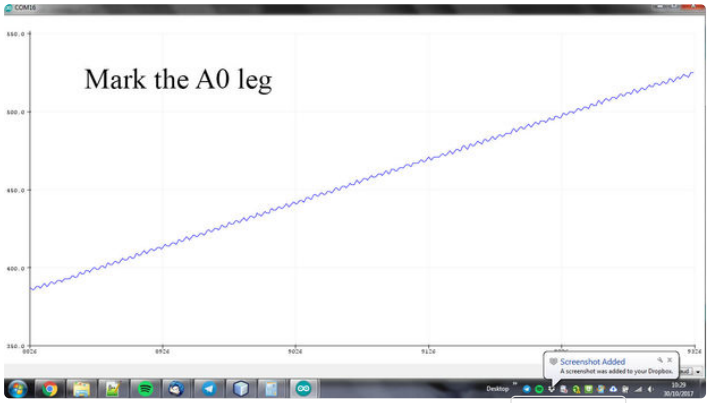
- Signal goes down or remains at 0. Then, mark the leg connected to GND.
- Signal goes up or remains at 1023. Then, Mark the leg connected to A0.
- It is important to not touch the transducers leg or the wires while doing that or the values will reset.

If it is still not possible to detect the polarity, poke the inside of the transducer with a thin wire and check if the spike goes up or down (like in the obsolete method). Spike up -> mark A0 leg, spike down -> mark GND.









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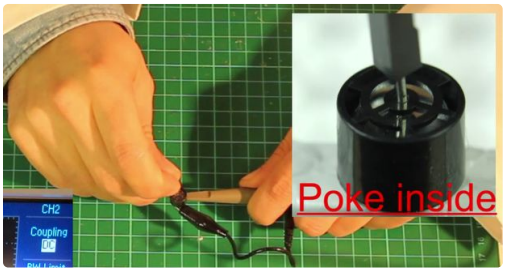
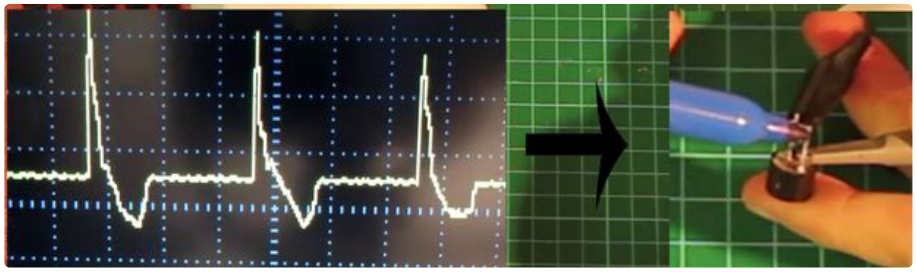
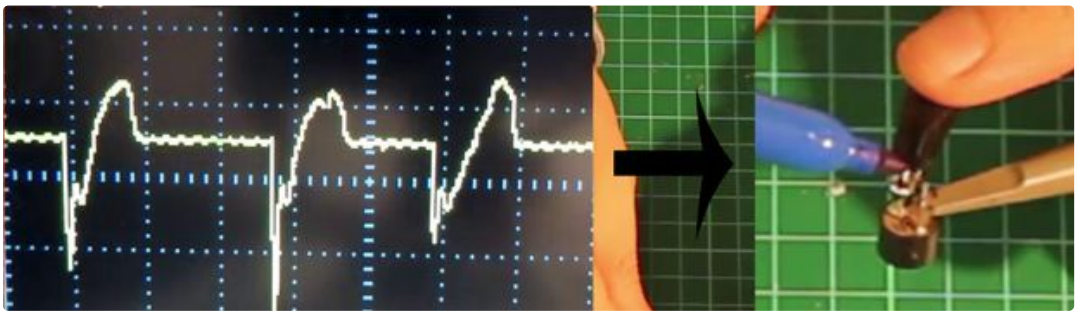
Step 6: Mark Polarity (Obsolete Method)

The transducers have polarity and it is important to glue them in the base oriented with the same polarity. Do not trust the marks made by the manufacturer, they are not reliable at all. The easiest way is to connect a transducer to an oscilloscope and poke the inside with a thin wire. If the spike goes up, mark the leg connected to the positive part of the probe. If the spike goes down, mark the leg connected to ground. You can use two stripes of copper to make this process faster. After all, you will need to mark 72 transducers.



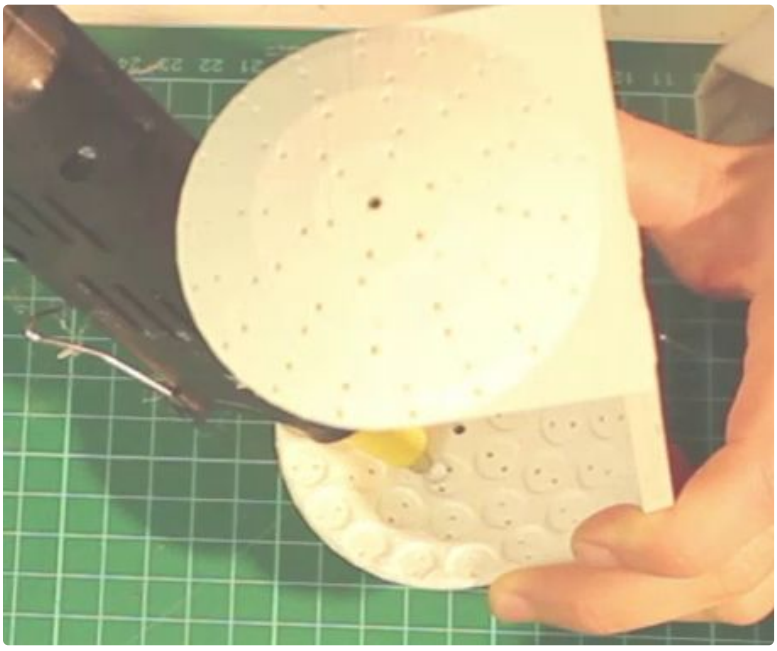


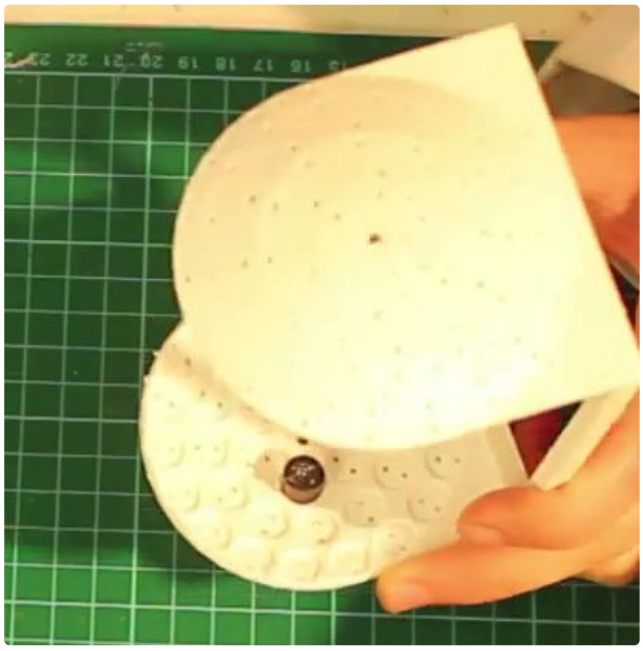


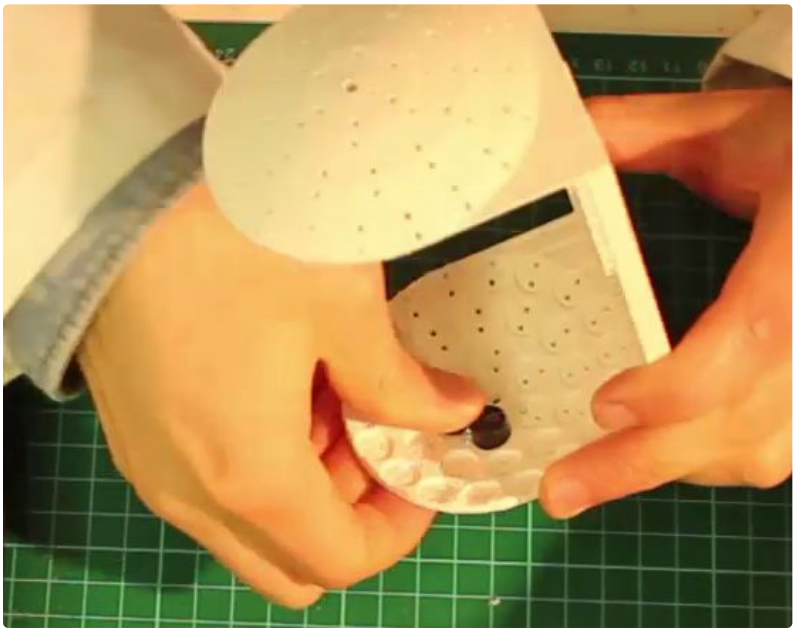
Step 7: Glue the Transducers

Apply a little bit of hot glue on the side of the socket (if you apply glue near the holes for the legs, the legs will be covered in glue when you push the transducers through), push the transducer in and apply some pressure with your fingers to make it lay as flat as possible in the socket.

It is very important that all the marked legs are pointing towards the centre of the device (where the hole is).

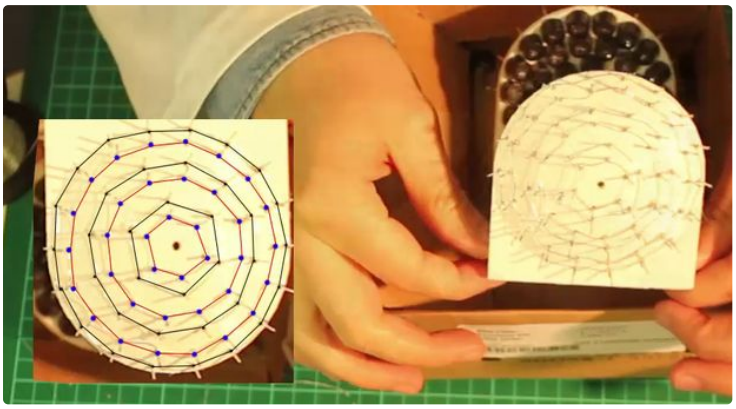






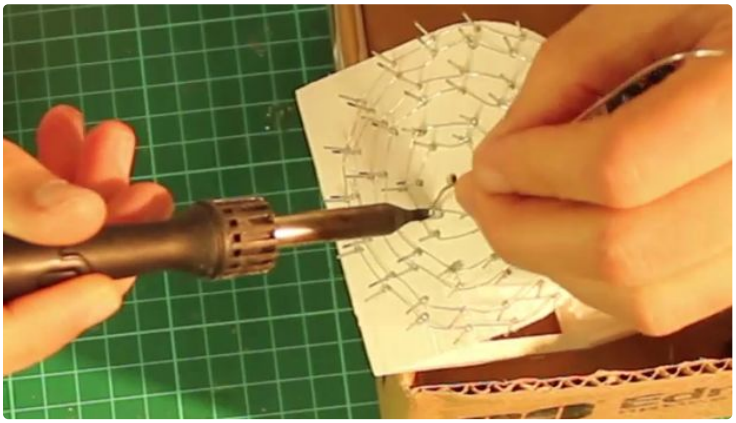
Step 8: Wire the Transducers

Wrap the exposed wire in six concentric rings around the legs of the transducers.



Step 9: Solder

Solder the pins to the wires.

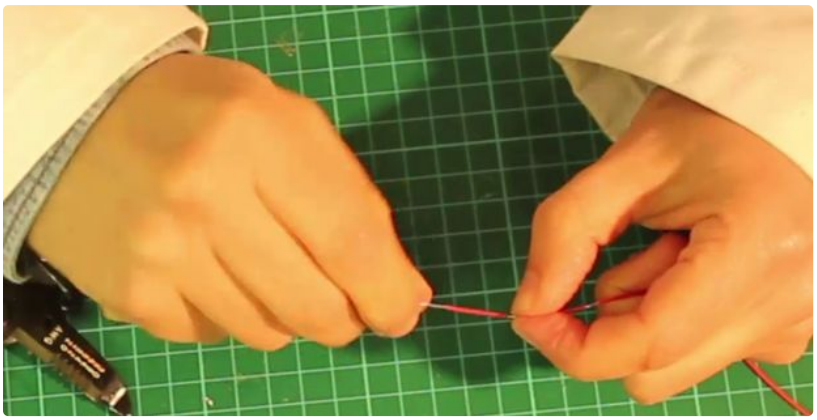


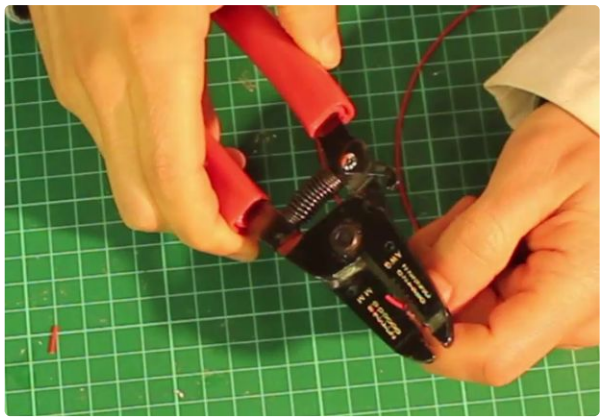
Step 10: Prepare 4 Long Wires

Now, we need to make the wires that connect the transducers to the driver board.

2 red wires and 2 black wires. They need to be around 1 meter. In one side there is only the tip exposed. On the other side there are 3 segments exposed, in the video it is shown how this can be done.

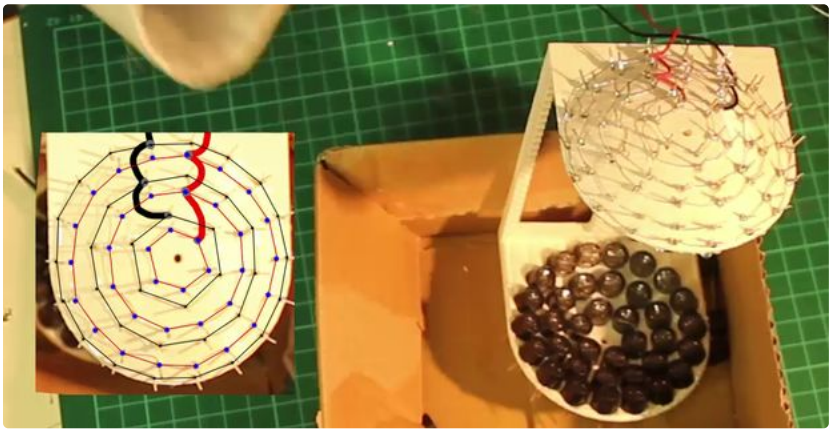
The side with 3 segments will go into the transducers rings and the side with only the tip will go into the driver board.

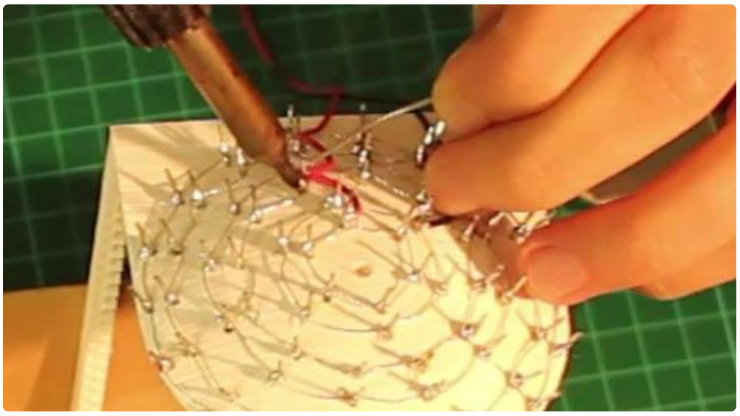
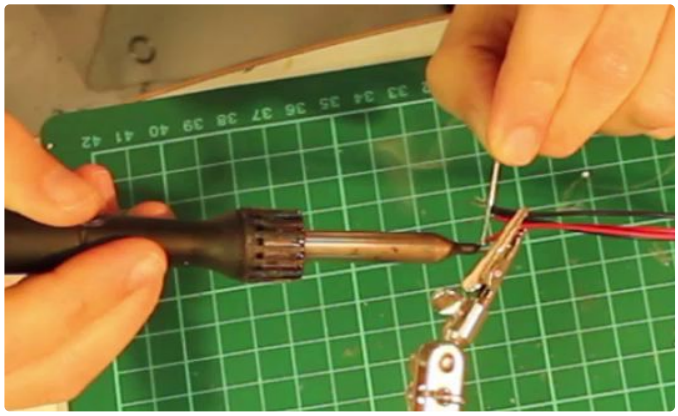




Step 11: Solder Long Wires

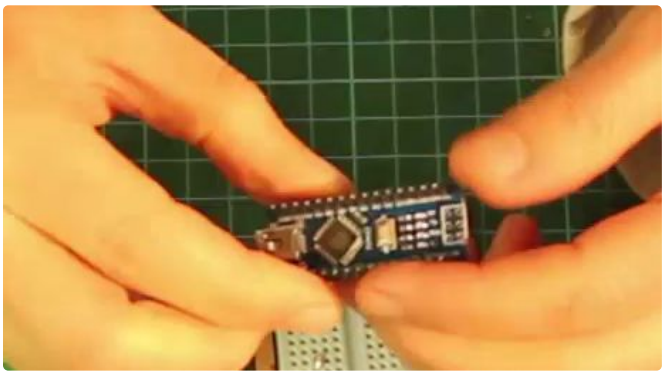
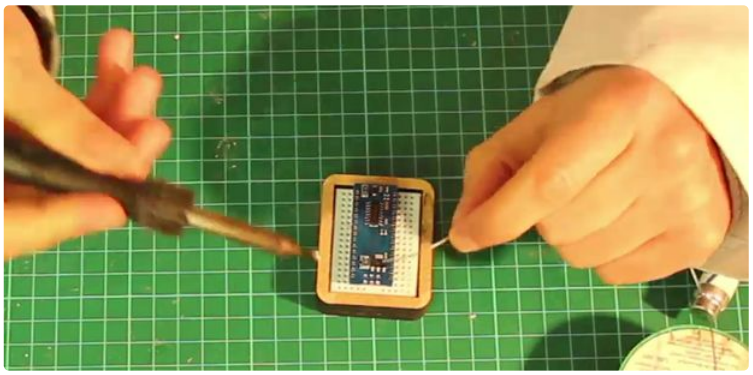
Solder the long wires to the transducers. The side with the 3 segments exposed goes into the transducers, one segment for each ring. Each side of the levitator has a black and a red wire. You can use flux and tweezers to facilitate the soldering. Tin the other sides of the wires (the side that only has the tip exposed)



Step 12: Solder Arduino Headers

Solder the headers of the Arduino, backwards if possible.

Step 13: Program the Arduino

Upload the code provided in this step into the Arduino Nano.

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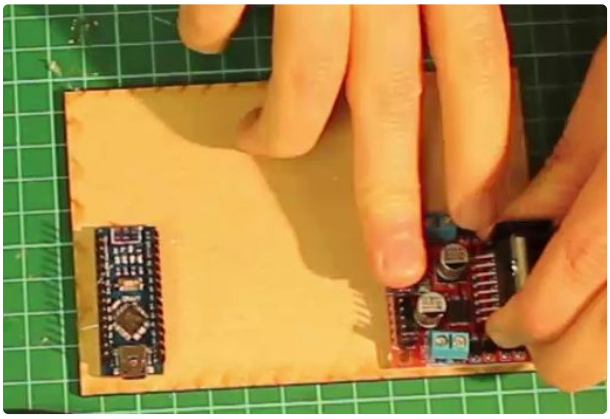
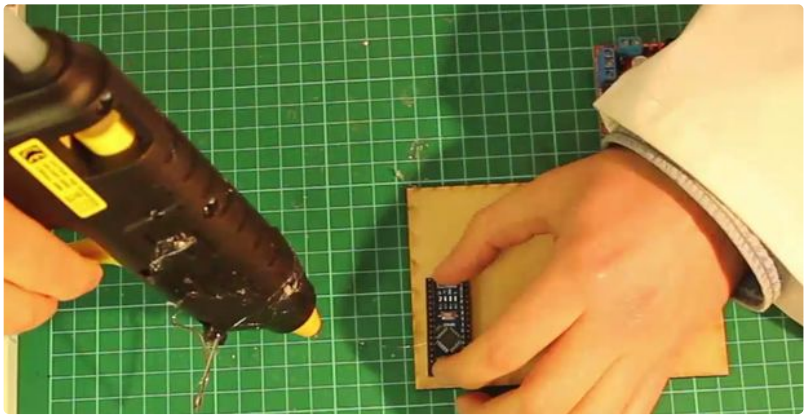
Step 14: Glue Arduino and Driver

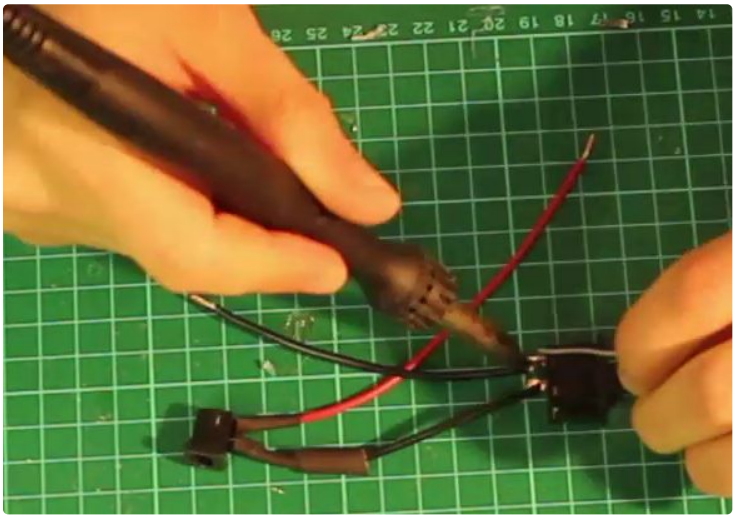
Glue the Arduino Nano and the Driver into the base. It is important to use the positions and orientations of the figures.





Step 15: Create the DC Supply

You will need to solder the DC female connector to the Switch and leave two wires prepared to supply power to the driver board.



Step 16: Glue DC and Wiring

Glue the DC connector and the switch.

Connect the red wire from the supply into the 12V input of the driver.

Connect the ground from the supply into the middle connector of the driver, also insert a male-female jumper there.

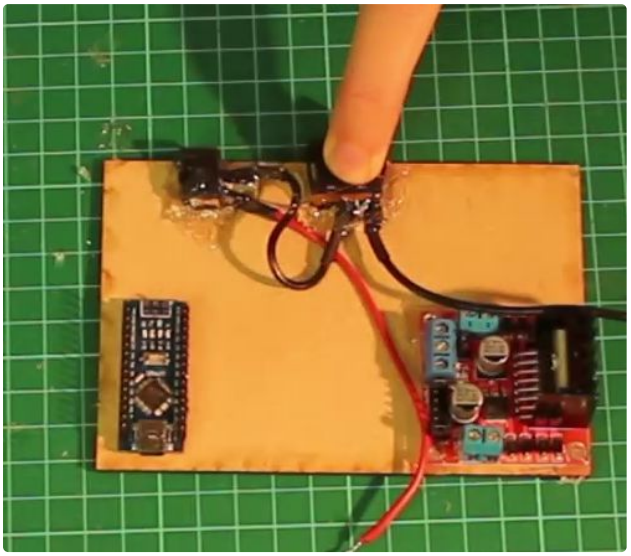
Insert a male-female jumper into the 5V input of the Driver.

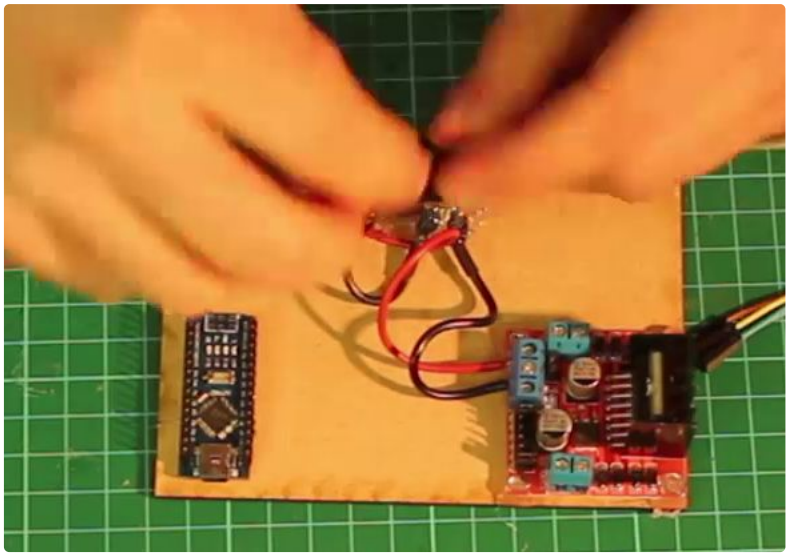
Connect the male-female jumpers that we connected to the driver into ground and 5V of the Arduino.

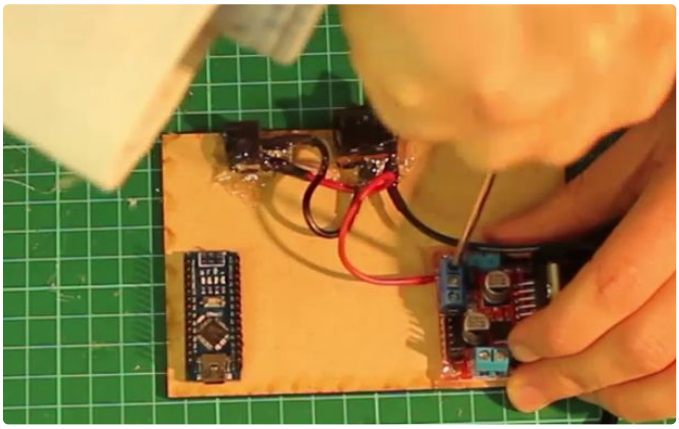
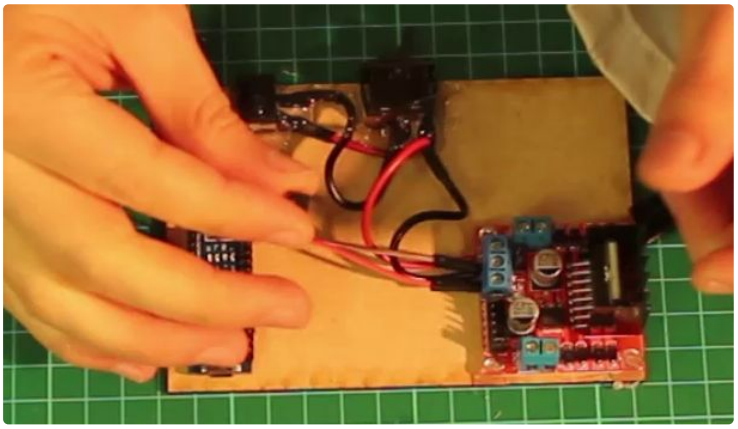
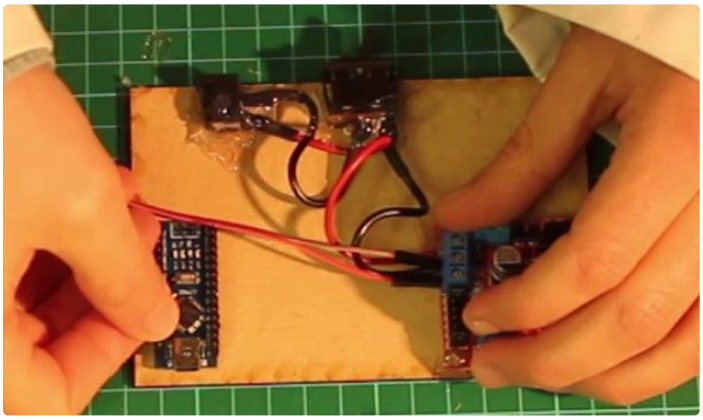
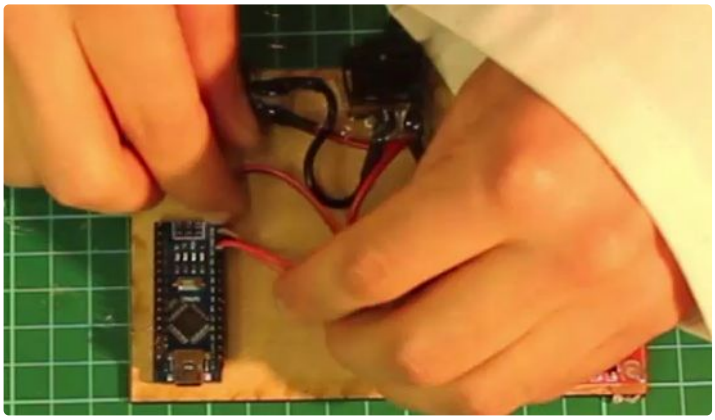
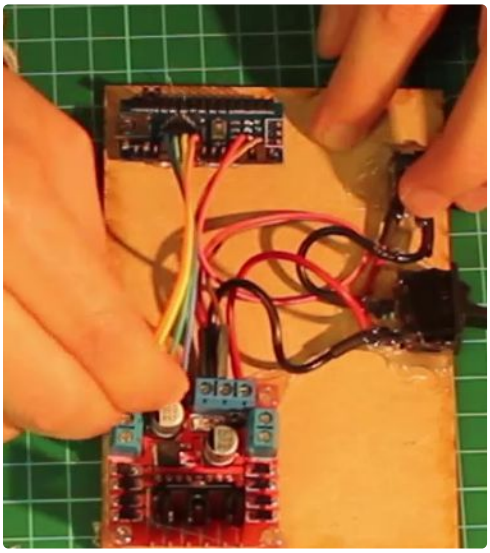
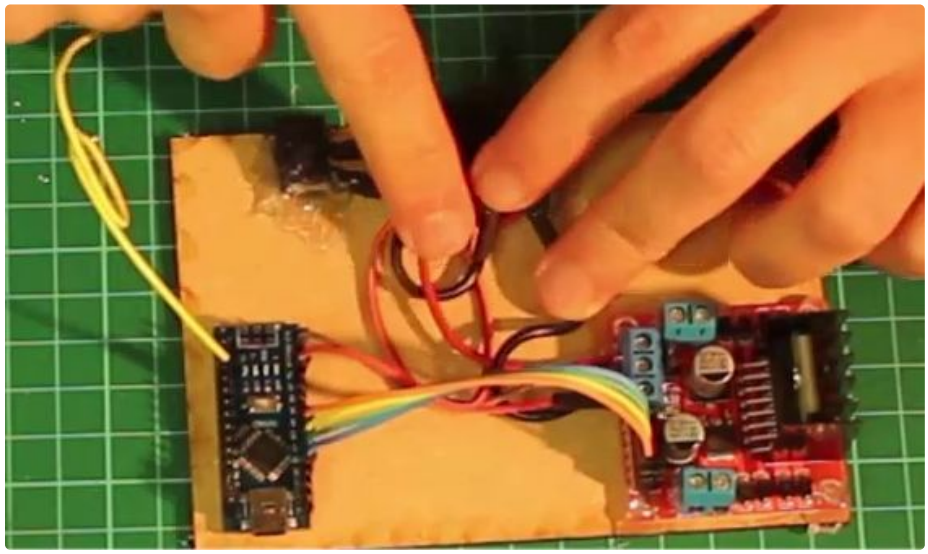
Connect 4 female jumpers from the Arduino (A0,A1,A2,A3) into the inputs of the driver (IN1,IN2,IN3,IN4).

Connect a female-male jumper into ground of the Arduino, this jumper can be connected to D2, D3 or D4 to move the particles up, down or reset them to their original position.

Connect D10 to D11 with a jumper. This is vital for the synchronised emission of the signals.

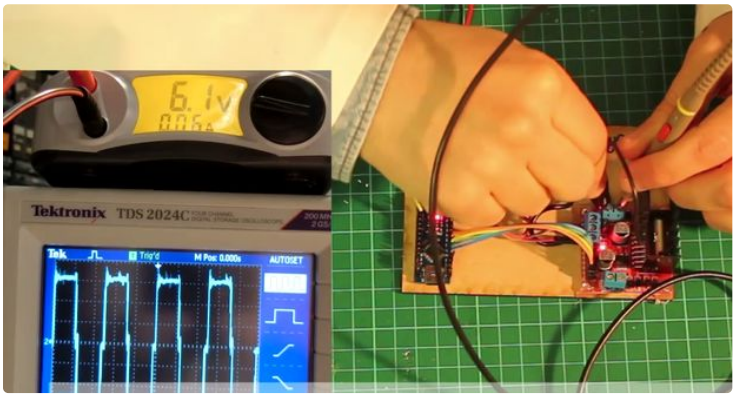




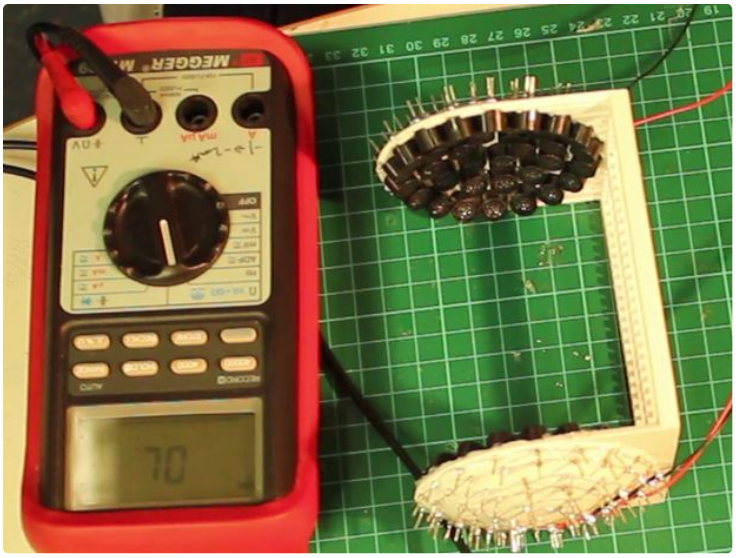
Step 17: Test the Driver

When powered (always between 6V and 12V) the output signals of the driver (IN1&IN2 or IN3&IN4) should output a 40kHz square wave of twice the voltage provided to the circuit.



Step 18: Test for Shortcuts

Test that there are no shortcuts between the red and black wires of the levitator.



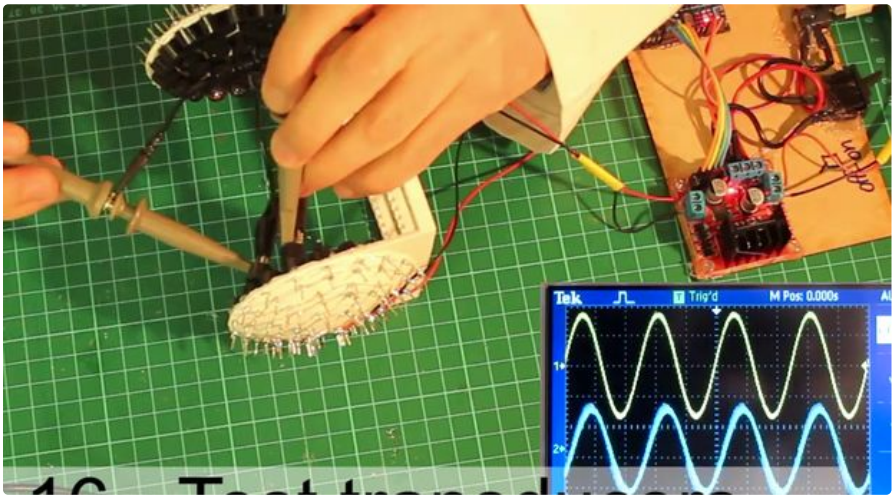
Step 19: Test the Transducers

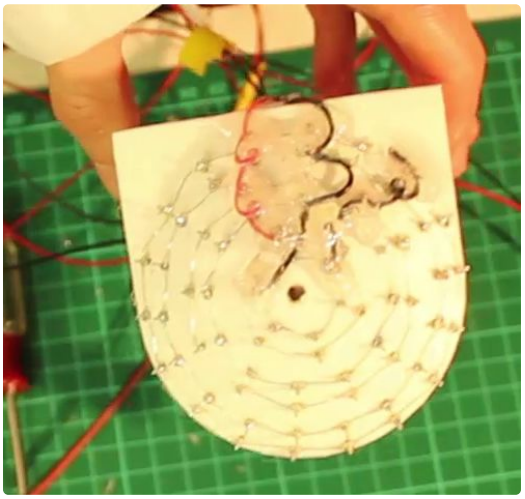
Connect the levitator to the driver board and switch it on (always provide between 6V and 12V). For testing, 6V will be enough.

You will need two probes with transducers connected (pay attention to connect the marked leg into the positive part of the probe).

Transducers of the same array (side) should be in phase.

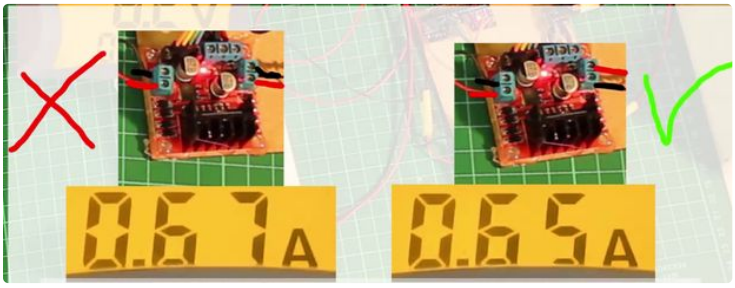
You can correct mistakes by cutting the exposed wire and bridging with wires.





Step 20: Test Optimum Resonance

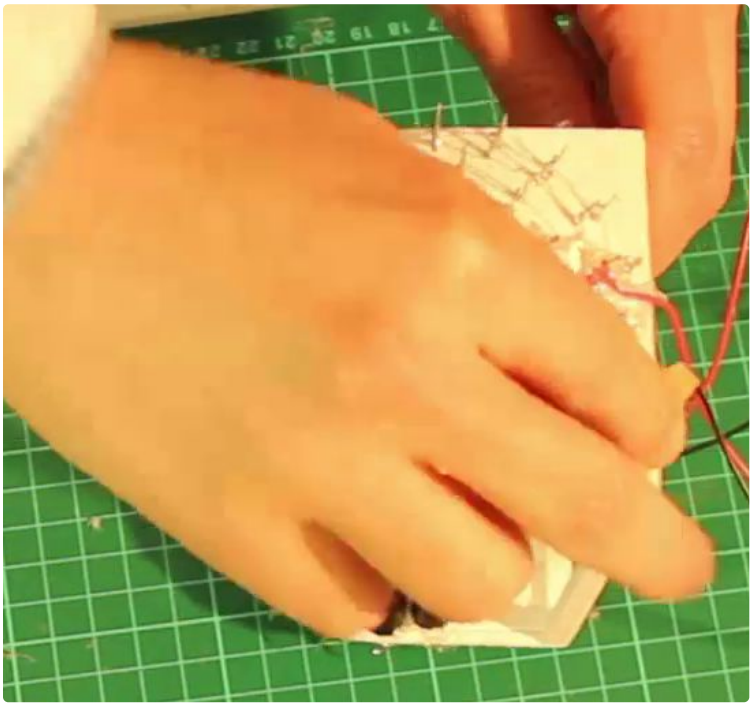
Connecting the wires as shown in the right should provide optimum performance and minimum power consumption. Otherwise, swap the red and black wire.



Step 21: Secure the Wires and Glue the Legs

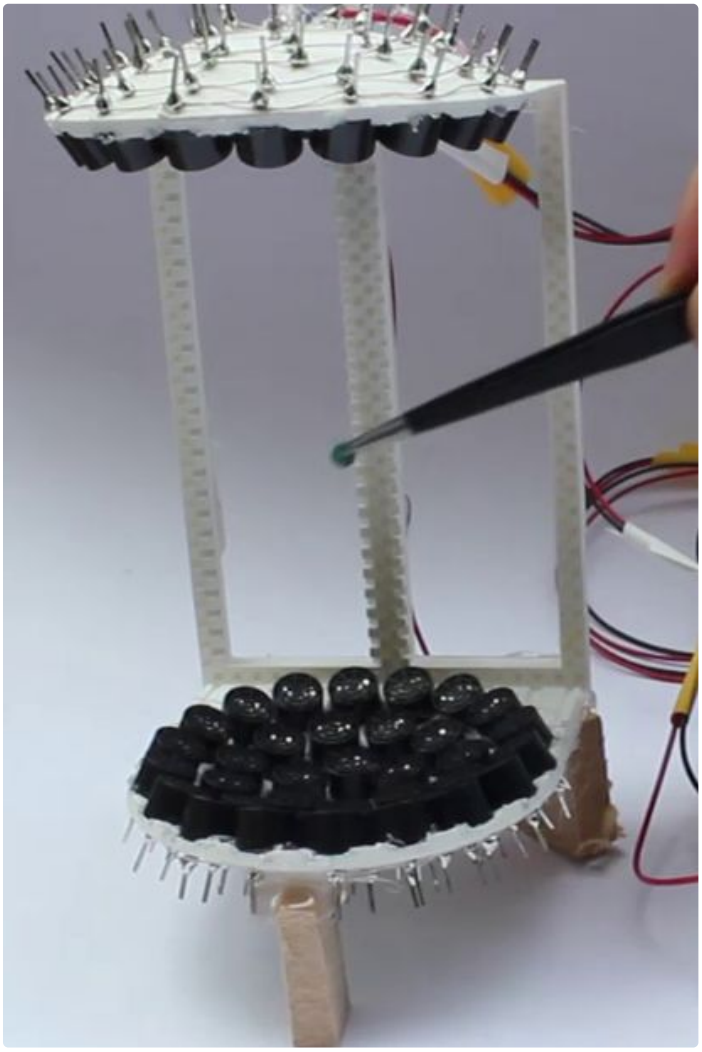
Apply some hot-glue to glue the wires to the levitator for mechanical support.

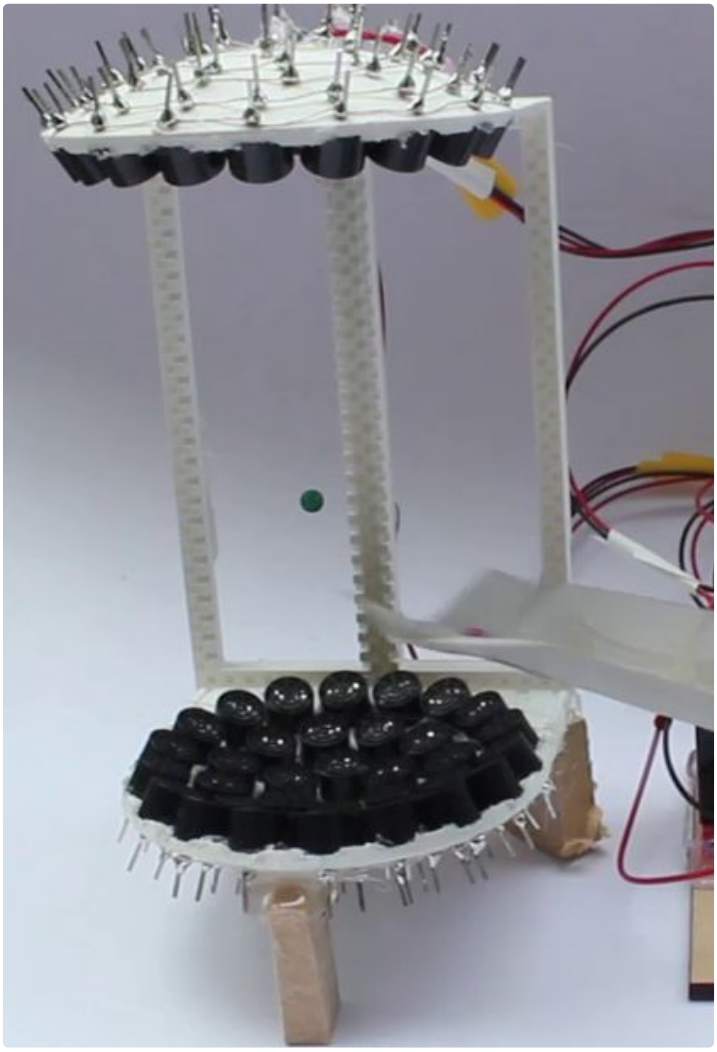
You can now glue the legs.

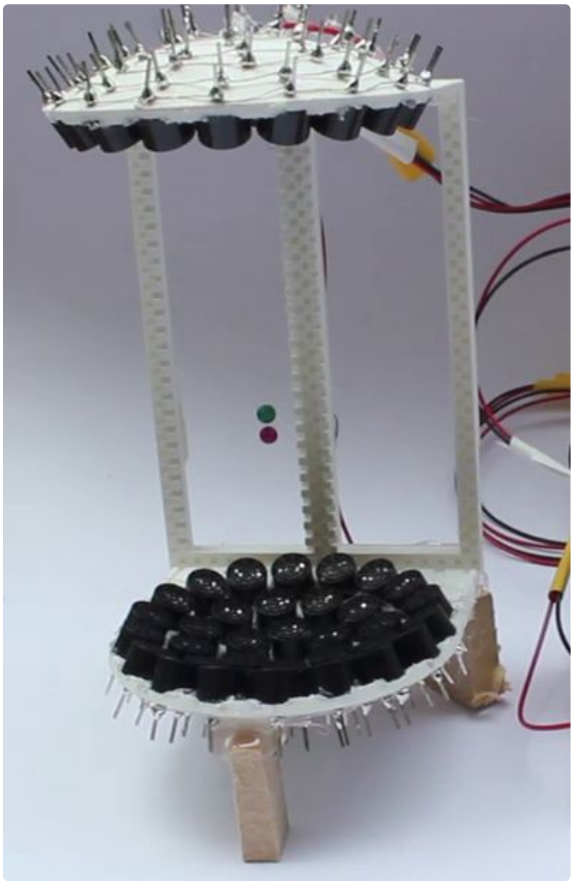


Step 22: Levitating Solids

Provide up to 10V. You can use a tweezer to place the particles. Also a metallic grid or thin fabric (acoustically transparent) will be useful since the particles can be placed there and then introduced into the levitator.







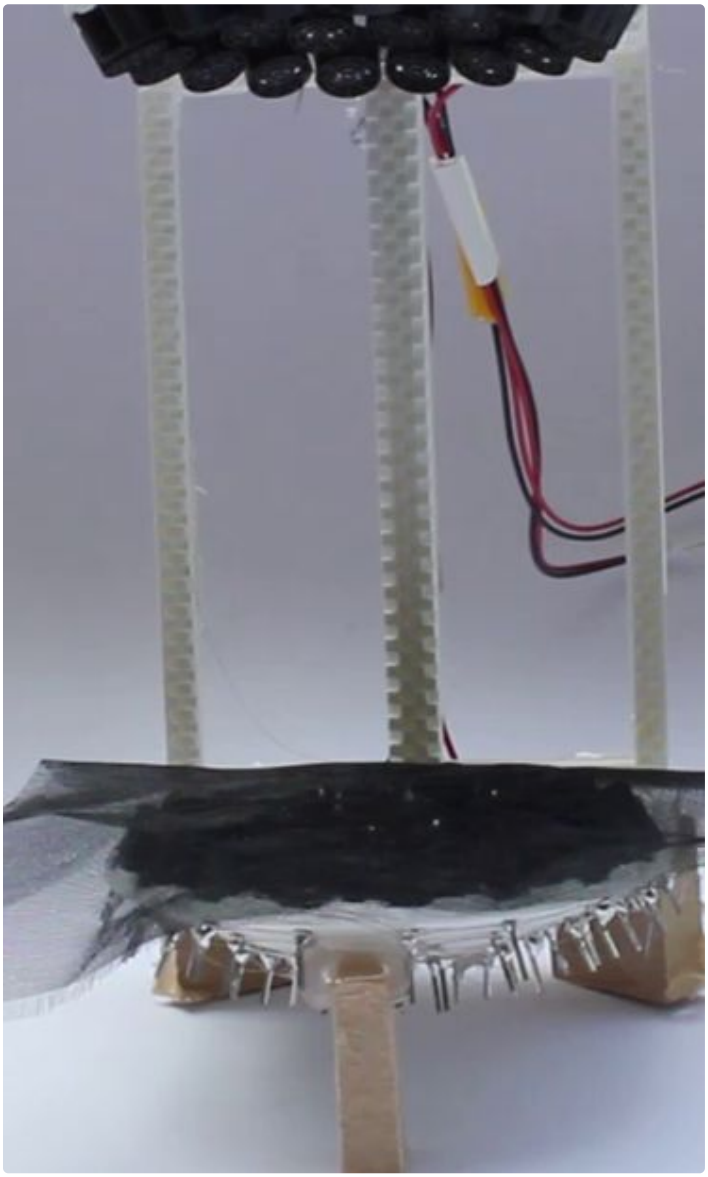
Step 23: Levitating Liquids

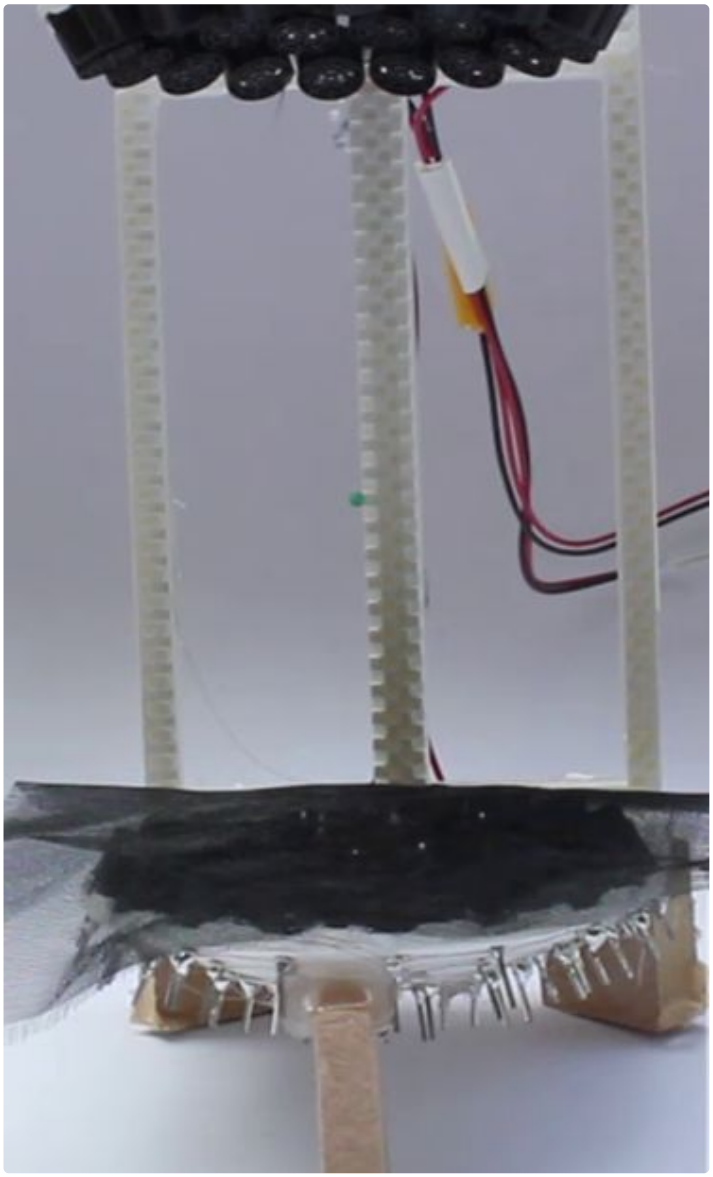
It is necessary to adjust the voltage to the type of liquid. Too high and the droplets will pop, too low and they will fall. For water around 9V is enough and for alcohol around 8V.

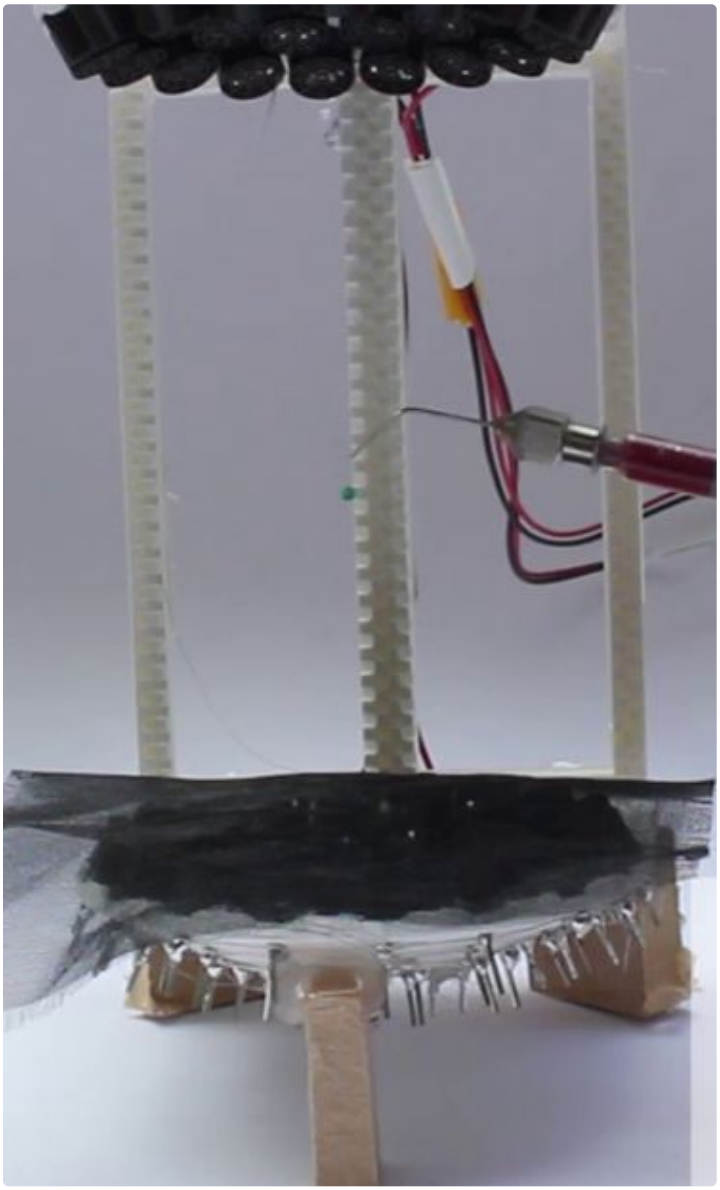
It is important to place a thin fabric on the bottom to absorb falling droplets, they can damage the transducers.

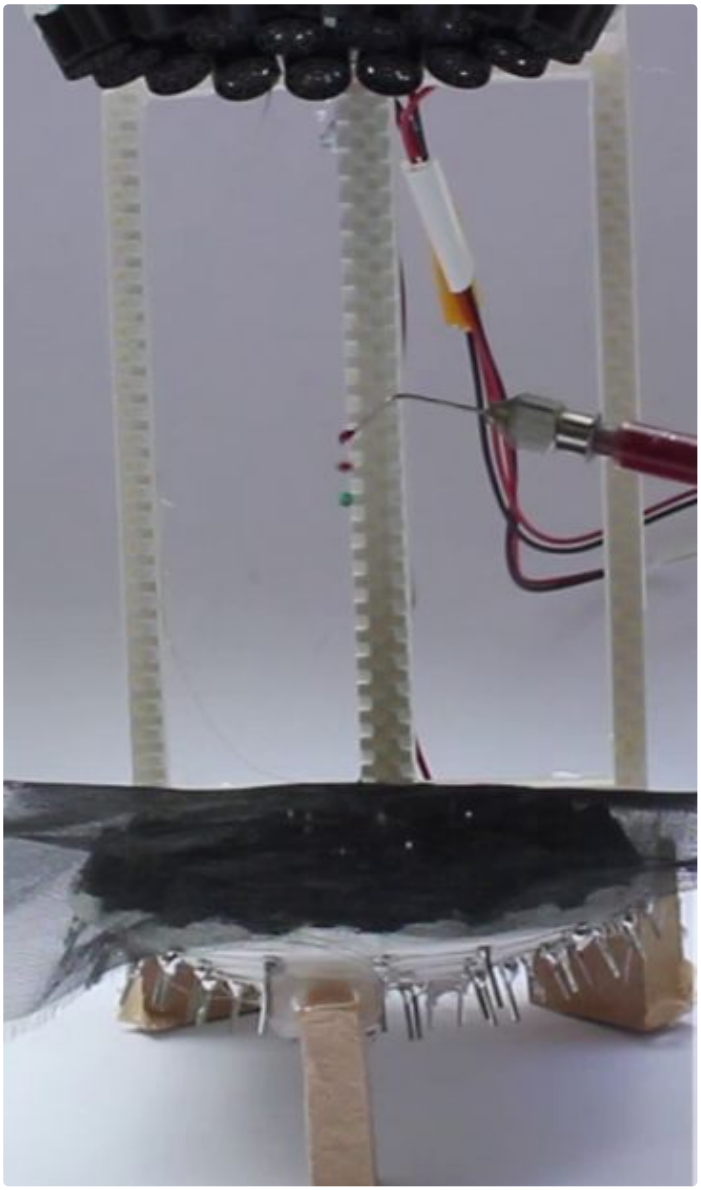
Place a particle to have a guidance of where to inject the droplets.

A syringe with a bent needle and the tip removed is the best option.









Step 24: BIGLev (optional Device)

If you want a more powerful levitator you can use the 16mm transducers. The process is exactly the same but you will need to 3d-print the levitator base in 2 part and glue them together (one half is attached in this step). This levitator can take up to 20V in the driver board (40Vpp) and levitate solids of up to 6g/cm3 but it is not as easy to use for liquids.

- 72x 16mm 40kHz transducers. Manorshi provides MSO-A1640H10

You can use instead 25kHz transducers, they are weaker but would allow to levitate larger objects. For that use the simplified code attached, and modify it to match your frequency.

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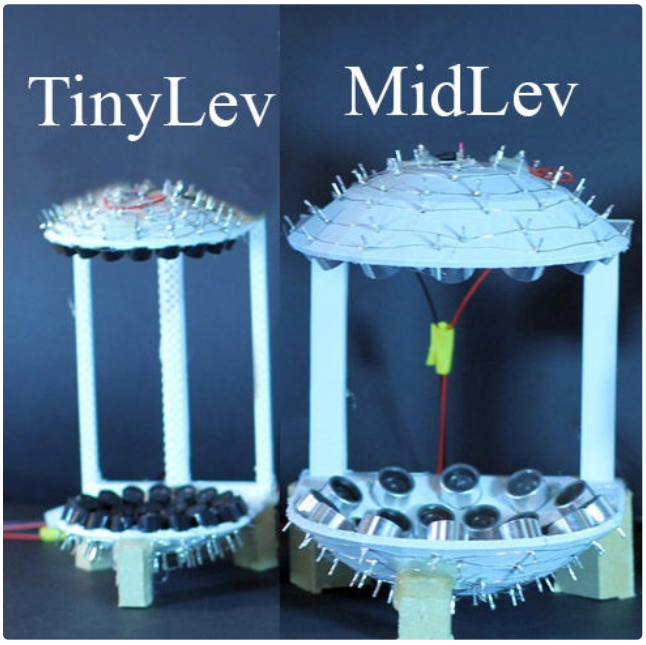
Step 25: Mid-Lev (Optional Device)

If you want to use 16mm diameter transducers but BIGLev is too big, you can use MidLev. It uses 16mm diameter transducers but it will fit most of the printers.



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Step 26: MiniLev (Optional Ultra Low-budget Device)

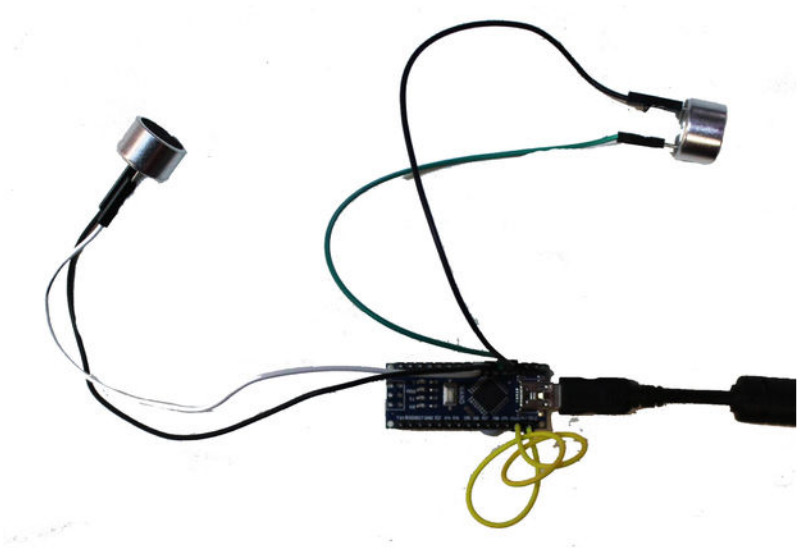
This solution only requieres an Arduino Nano and two transducers. You can desolder the transducers from a cheap Range Finder HC-SR04.

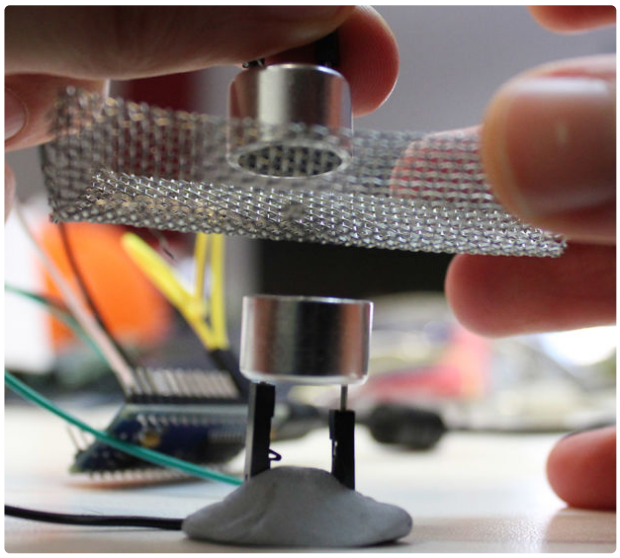
Install the provided Arduino Code from Step 12. Connect pin D10 to D11. Connect one transducer to A0 and A1; and another transducer to A2 and A3.

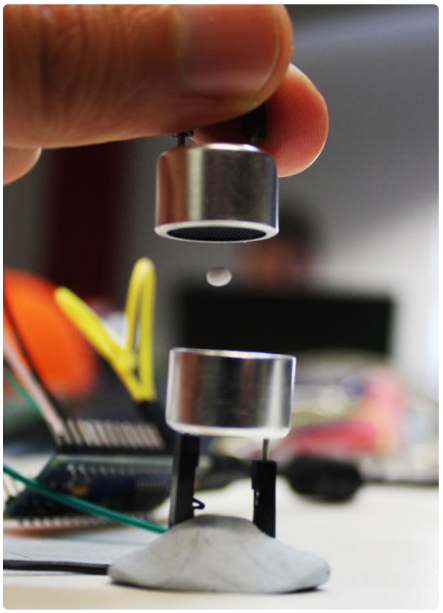
Put the transducers opposite to each other to levitate a particle between them, it is easier to place the particle with a metallic grid.

You can use this 3D-printed case designed by IB-as.

You can also use the simplified code by morlok.

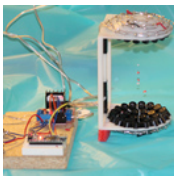






Thank you so much for your detailed guidance! When D2, D3 or D4 is connected to ground, I observed that the object moved up and down, which made me feel very magical. But when I was learning the code, I was wondering how this was done. Actually, I am a beginner. Can you teach me which part of the code this function corresponds to? What is its basic principle? I want to try to modify it, thank you so much!

I built my TinyLev from the kit sold by MakerFabs.
I got the kit within a few days and assembled it within a few hours.
Just the transducers would have taken a few weeks to get from China.
Great project, thanks



Hi, I made a biglev, but it was not quite right, it's hard to levitate, I use your code but it's almost can't levitate.The bean floated away.Thx

have you tried with a small (1 or 2mm) styrofoam sphere. Kindly check the video at the end.

I have successfully built, but the levitated object does not stay still, but slowly moves to the array on one side. What causes this result? Please help me!

D2, D3 or D4 being connected to ground. You only do that as button to control the movement.

err I mean what the solution thx XD

Thanks

Our goal for now is to try to levitat sand particles first. I'm not sure about the density but I think it's pretty heavy compared to a little piece of paper with the same dimensions. Is it normal to not be able to levitate sand or is it a problem with the whole system ?
Thank you for your answers.

Hello. When I check polarity of my transducers and connect the plus leg to the A0 and the other to the ground using jumper wires I get the signal going up sometimes which mean that the positive leg marked by the manufacturer should be marked and sometimes the signal going down meaning

the other leg should be marked. But isnt that correct as the positive leg should be showing a increasing signal and the other leg decreasing which mean I need to connect all the marked by the manyfacturer positive legs together and the other ones together too?

No, the manufacturer markings are random. That is why you need to mark them yourself.

Hello. I wanted to know if it would be possible to make the particles go up and down (similarly to what is displayed in the other youtube videos. Does this DIY version can also do that? What would I need to chage specifically for the particles to move?)

If you check the video at the end it is shown how to move the particles up/down, this setup is designed for it.

Very cool project. Looks cool and the physics part is cool. But one question springs to mind after checking out the specs on the ultrasonic transducers: Given that each transducer outputs somewhere near 112dB on 10V - wouldn't 72 of them be like 131dB of sound - even though the human hearing doesn't perceive this wouldn't it be somewhat dangerous to the ears - given that we are in fact pushing air equalling the sound of an F16 taking off? Just curious about that. Has anyone experienced any problems with having this on for prolonged periods of time?

No, you also have the companies uBeam o Ultrahaptics using ultrasonic beams. Although I would recommend not to put the ear nearby the transducers.

hi, my midlev's maximum Pa is around 300pa, but I can not levitate any droplet(include water). I don't know why. What is the sound pressure of tinylev for levitating water droplet? thanks!!

After trying to test the polarity the transducers we observe rectangular signal instead of sinusoidal signal at the final test of the phase.why?and thank you so much

You would only read rectangular signals on the electric signal, the "audio" signal read with a transducers should be sinusoidal. Are you connecting the scope directly into an emitting transducer?

My adaptor is just reading 3volts in the multimeter.. but it shows 9volts output on the label.. and now I'm not able to check my driver due to the low output voltage.. pls pls pls suggest a solution... it's urgent..

Any luck with this? sometimes the adaptors have buttons to show the input or the output.

It’s been on display and running for 3 days. so far it hasn’t dropped anything. I did add a laser and I have it plugged into a battery backup

Thank you for your reply. I got the oblate droplet. How can I add voltage modulation to achieve the droplet shape oscillation? I saw the droplet shape can do the shape oscillation by some actively voltage variation. Thank you very much!

regulated power supply. Or use the simple code on the Arduino (the one that does not change the phase) and will allow you to change the duty cycle of the 40 kHz signal, which is equivalent to modulating the amp.

I have this same problem. I'm definitely not touching anything, am using jumpers and gator clips. No fingers touching anything and very confusing results. Is there not a way to test with a multimeter instead?

Hello. In the code in lines 51 through 67, there is text that looks like it should be code but it is marked as a comment with the usual /* before it and */ after it. Should I remove these and make it code or was this intentional?

You do not need those lines.

Thank you! By "they are usually the same", do you mean that the receivers can produce acoustic waves too, or that they only act as refelctors of the waves produced by the transmitters that I place on the other side?
Thank you so much!

I mean that they are literally the same.

If they're the same, why are they marked "T" and "R"?

I have no idea. But they also have the polarity marked and it is totally wrong.

I just tried it; transmitting between two modules separated by 20cm:

Transmit "T" to Receive "R": 1.8V
Transmit "R" to Receive "R": 0.56V
Transmit "T" to Receive "T": 0.28V
Transmit "R" to Receive "T": 0.08V

So, it works swapping R and T, it just doesn't work very well...

Hi! We have built a TinyLev using your premade kit but we have run into some problems. The frequency is irregular and we can hear the trancducers from time to time. Any help would be appreciated.
Thanks!

But is it working? How do you know the frequency is irregular? sometimes when something falls inside the transducers they make some noise.

We can barely get anything to levitate for more than a second and after this it gets thrown out. There is no consistent standing wave. Do you have any idea what might cause this?

Yes D10 is connected to D11, I tried with cotton but it does not work. What kind of particles do you recommend me to use?

Pieces of polystyrene works great

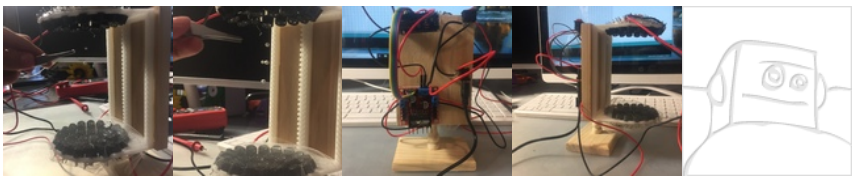
Indeed, small particles of styrofoam (expanded polystyrene) work the best.

Hi
I have armed the acoustic levitator, but I can not make it lift anything. All the LED's turn on, and you can hear a slight buzz from the transducers, but I can not lift anything.

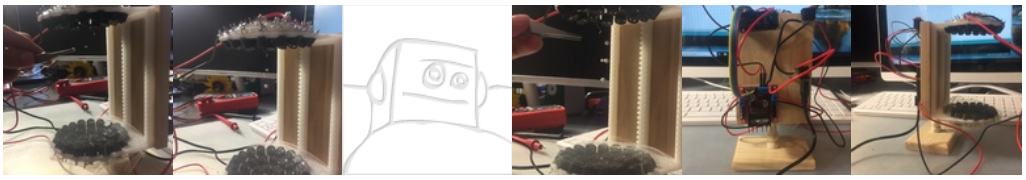
Are D10 and D11 pins connected ?

Yes, they´re

works on styrofoam balls, observed some can pop up.

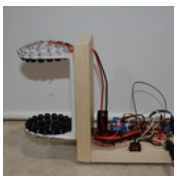


skieshface made it!



Works and fairly easy to build!

Had little trouble a first I was trying to levitate to big of particle. Works great



I have downloaded the Ultraino file and ran it, but it kept reminding me that I lack a file and there are some errors in the code.

The file is called acousticfield.AcosticField3D.

The light is green. I tried multiple positions with the transducer, none worked. Thanks for the quick reply!

Where do you change the voltage? Do I need a different item?

"You will need a regulated power supply"

Thanks