Build a Professional Vocal Booth on a 500 Dollar Budget

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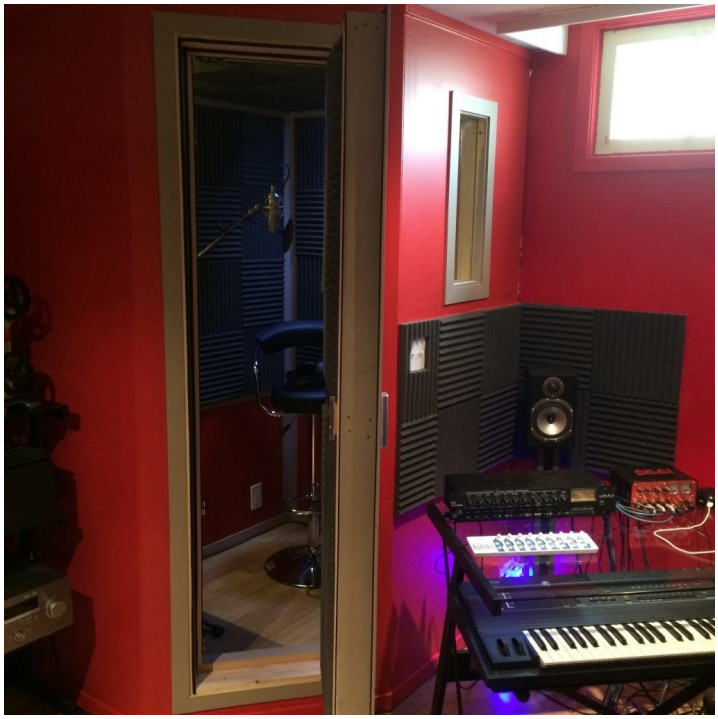


The finished vocal booth – $500 build; very effective noise reduction, comfortable, and functional.

My **home recording** space is primarily used for **voice-over** work. Doing voice-over or voice acting in a **home-studio** has two main drawbacks:

1. **Daytime – Noisy recordings**: Appliances, fighting children, traffic, and construction noise is guaranteed to ruin a good take.
2. **Nighttime – Disturbing others**: To avoid interruptions I often recorded voice overs late at night. But my voice booming through the house at 1:30am is generally met with disapproval.

The solution was to create a recording space with excellent sound *damping* properties. Notice I avoided using the term *sound-proofing*. A truly sound-proof space requires thousands of dollars. I had a **$500 budget**.

Objectives

1) **Size:** Just large enough for me to sit/stand and perform voice-overs without banging a wall or mic stand.

2) **Comfort:** I'd be spending a lot of time in this booth, so it had to feel right – comfortable. The lighting had to be adequate for reading scripts, but not to harsh. Comfortable seating. A window to stave off claustrophobia. And ventilation – for safety reasons – because the booth is essentially an airtight chamber.

3) **Acoustics**: Above all else, *the **vocal booth** must be **quiet***; reducing outside noise from bleeding into my recordings, and containing my voice so it doesn't disturb others. Equally important, the inside of the booth needs to sound very neutral – not boxy or boomy.

4) **Budget**: $500 (Canadian). This is insanely cheap compared to other vocal booths and plans – but it's all I can afford at this point. Like Matt Damon's character in *The Martian*, I had to "science the shit out of this".

The Science

I have decades of live and studio recording experience, so between me and my trusty side-kick *Google*, we were able to come up with a plan for a **vocal booth** that is both **quiet and affordable**.

But first, some (yawn) physics

- High frequency noise (birds chirping, little yappy dogs, telephones, etc) is made of low-energy sound waves which are fairly easy to eliminate – like little ripples on the surface of a pond that you can block with your hand.
- Low frequency noise (heavy footsteps, the rumble of traffic, booming construction) is made of high-energy sound waves and requires more effort to reduce – like rolling, crashing ocean waves that can flatten a beachfront house.

Ways to eliminate unwanted sound

1. **Cancellation**: Sound waves are cancelled when they meet a mirror image (inverse-phase) – this is called destructive interference. There are electronic devices that use cancellation to wipe out ambient noise, but this process introduces undesirable audio artifacts and degrades recording quality – so cancellation is **not an ideal solution** for noisy recordings.
2. **Reflection**: Some materials possess high sonic reflectivity – these are usually hard, smooth, rigid surfaces, like concrete, stone, hardwood, and metal. These materials are unforgiving and don't resonate, so the sound wave bounces (reflects) right off. This is very useful, especially for high frequency sounds – so reflection will be partly responsible for the sound damping of our vocal booth.
3. **Absorption**: Some materials will absorb, rather than reflect sound – especially high frequency (low energy) sounds. These materials tend to be porous like Styrofoam, which we will use for surface treatment to control reflection *inside* the vocal booth.
4. **Dissipation**: Different materials reflect and/or absorb different frequencies. Building a wall with many layers of materials with different properties is an effective way of disrupting a broad spectrum of noise. This vocal booth will have many layers.

Using a combination of **reflection and absorption techniques**, I was successfully able to block a substantial amount of noise in the typical human range (20-20,000Hz). As I said from the beginning, it's not 100% sound proof, but it is effective enough to block the types of noise that were causing 95% of my problems.

Building the Booth

Placement

To reduce the costs and improve the overall effectiveness, I recommend placing the booth in basement if possible – where the room's walls are made of concrete. If this is not possible, find a space in your home that is somewhat isolated – away from furnaces, laundry appliances, water pumps, etc. – and choose a corner where the walls are most dense; probably the exterior walls of your home.

Materials List

Prices of building materials fluctuate between seasons and regions, so I won't publish many costs. Suffice to say, I did my homework and selected the best materials for the job within my $500 budget.

- **Insulation**: 1x bundle. Roxul Safe-n-Sound.
- **Frame**: 20x spruce studs (a.k.a. "two-by-fours"). 96″ x 1-1/2″ x 3-1/2″.
- **Casing**: 6x premium pine boards. 96″ x 6″ x 3/4″.

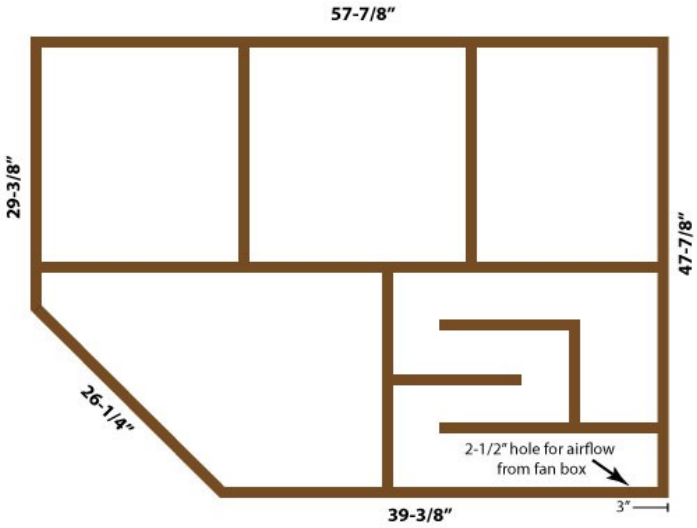
- **Trim**: 12x flat pine baseboard. (no scrolls). 96″ x 3″ x 1/2″.
    - ALTERNATIVELY, you can save a lot of cash and make your own trim by ripping 2×4's lengthwise. It's good way to lose a finger/hand/eye so be careful if you choose this route.
- **Flooring**: Laminate. 20 sq.ft.
- **Drywall**: 3x sheets gypsum board. 96″ x 48″ x 5/8″.
- **Other Wood**:
    - 4x sheets OSB (oriented strand board). 96″ x 48″ x 3/4″.
        - *NOTE: In the video I used 1/2″ OSB, but in hind-sight 3/4″ would have been better.*
    - 1x sheet spruce ply-wood. 96″ 48″ x 1/2″.
    - 1x small sheet MDF. 24″ x 24″ x 1/2″
- **Glass**: 2x panels. 22″ x 8″ x 1/4″.
- **Acoustic sealant**: 2x 300ml tubes Acousti-Seal.
- **Construction adhesive**: 4x 300ml tubes Foam Board Adhesive.
- **Clear Silicon window caulking**: 1x 300ml tube.
- **Spray foam expanding insulation**: 454g can.
- **Closed cell, rubberized foam tape**: 1x roll. 100-feet x 1/2″ wide, 1/4″ wide x 1/8″ thick.
- **Screws**:
    - 4″ wood screws. 1/4-lb
    - 3″ wood screws. 1/2-lb
    - 2-1/4″ wood screws. 1-lb
    - 1-5/8″ drywall screws. 1/4-lb
- **Finish nails**: 1/4-lb
- **Door hinges**: 2x standard 3-1/2″ hinges.
- **Vent covers**: 2x grills. 4″ x 10″.
- **Magnetic cabinet latch**: 4x.
- **Light switches**: 2x
- **Switch cover plate**: 1x two-gang.
- **Switch box**: 1x two-gang.
- **Computer Fans**: 4x quiet fans. 80mm, 12VDC.
- **LED Light strips**: 2x surface mount, 12V. Approx 12″ long by 1″ wide.
- **Wire**: 50-ft. 16AWG 2-conductor insulated copper wire*
    - *NOTE: All electricals in this booth are 12VDC. The full current draw is less than 0.2 Amps. Consult an electrical professional if you don't know what this means.
- **Power supply**: 1x 500mA, 12VDC.
- **Acoustic foam**: 48x panels. 12″ x 12″ x 1″ Acoustic Wedge Foam.

NOTES about Materials:

1. The acoustic sealant is EXTREMELY MESSY to work with. I'm not 100% convinced that it's effective when used as we're using it – If I was to do this over again, I might consider replacing it with construction adhesive.
2. Consult your local electrical code regarding the use of 12VDC lights and fans. If you're not familiar with electrical, consider hiring an electrician.
3. Speaking of cheap … I bought locally where I could, but some things were only available on-line, and some other things were just too expensive to buy locally.
    - Of note: I bought the 12VDC fans on ebay. They came from China and cost $1.50 each including shipping.

- I shopped the world and found the best deal on acoustic foam at The Foam Factory: http://www.thefoamfactory.com/acousticfoam/wedgefoam.html

4. Recycle or Up-cycle where possible. I scavenged the LED panel from a discarded laptop and used it as a surface mount ceiling light.



The Floor

The measurements in the diagrams are rough/rounded – i.e. not exact, so don't use them. Every room is different – so do your own measurements to meet your needs.

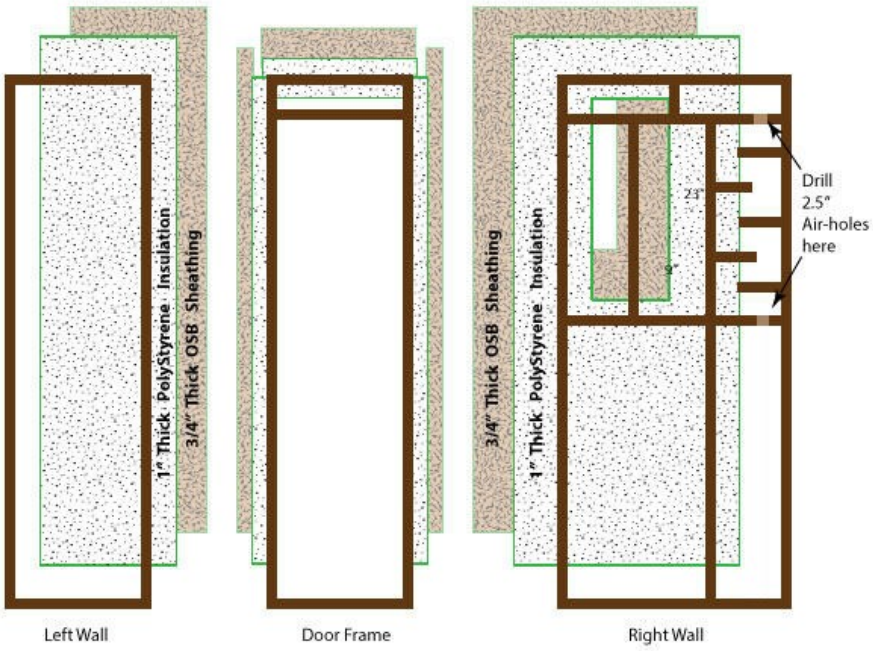
The ventilation maze in the subfloor will allow the fan-box to push fresh cool air up into the booth from outside. The maze design allows for air-flow, but reduces sound wave transmission.

Build the Subfloor

The subfloor is the foundation of your vocal booth. Everything else is built on top of this. There cannot be any squeaks or movement in this subfloor, so don't be stingy with the screws. A little glue wouldn't hurt.

- Start by sketching out dimensions that will work in your studio space. Use the above image as a guide.
- Measure and cut your studs. Lay them out to confirm everything fits together.
- Screw it together with 3″ wood screws.
- From the leftover ends of 2×4's, build ventilation maze. (more on this in the ventilation section further down)
- Using a 2-1/2″ hole-saw, drill one ventilation hole for the air-exchanger in the side of the subfloor-frame. The hole should be 3″ from the right corner.
    - *Carefully Measure EXACTLY where this hole is – you will need to drill through the drywall here later.*
- Flip the subfloor-frame over – bottom-side-up – and apply a strip of rubberized closed cell foam tape to every segment of the underside. This will further reduce any chance of a squeaky subfloor and help prevent wobbling. It will also create a seal against the real room-floor and improve airflow through the ventilation maze.
- Flip it the subfloor-frame back over so it's right-side-up again – with the tape on the underside.
- Cut a sheet of 3/4″ OSB exactly to size. Lay it on top of the subfloor-frame to check the measurement – should be a perfect fit with no overhang – then remove it and set it aside.
- (CAREFUL here – this is messy step). Apply a generous bead of acoustic sealant compound to the entire top surface of the subfloor-frame. With help, carefully position the OSB on top of the subfloor-frame. Screw into place with LOTS of 1-3/4″ wood screws. Wipe away any sealant that squeezed out between the OSB and the frame.
- Finally, drill two 3-1/2″ holes in your new floor, for air (See the diagram above).

The Walls



Make the Wall-Frames

- The left (short) wall is a simple rectangle. Mine is 30″ wide, but measure yours to suite your space. Measure so it extends from the surface of the subfloor up to the actual room ceiling.
    - In my case, the room ceilings are 7'6″. If you have really high ceilings, make your booth walls as high as you need – 8″ is probably good.
- Likewise, the door frame is a simple rectangle, approximately 26″ wide, with a header 6″ from the top.
    - This 26″ wide door-frame will allow for only a 19″ door after we build a sound-seal. If you need a wider door, adjust your measurements accordingly.
- The right wall has 9″ x 23″ opening for a window, and another ventilation maze – similar to the subfloor.

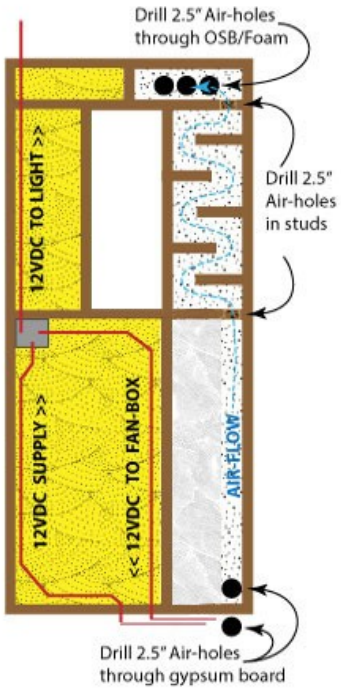
Cover the Wall-Frames

- Cut 3/4″ OSB panels to exactly match the left and right wall-frames.
- Cut 1″ Polystyrene Foam Insulation to exactly match the left and right wall-frames.
- Carefully cut the window opening in the right-panels.
- Using acoustic sealant, laminate the left OSB & foam panels. Do the same for the right panels. Set these aside.
- With the left and right wall-frames lying flat, apply a single bead of acoustic sealant to the surface of the frames.
- With help, carefully position the OSB/Foam panels onto the matching frames.
- Align exactly and screw the OSB/Foam panels into place.
    - Use a minimal* number of 2-1/4″ wood screws. *(*screws provide a medium for sound vibrations to travel through the wall, so use as few as possible – one in each corner and another every 24-inches)*
- Wipe away any excess sealant that might have squeezed out from between the panels and frames.

Erect the walls and door frame

- Stand up the left wall so it it sits flush with the corresponding edge of the subfloor – OSB will be the inside of the booth. The exposed studs are facing outward. Using 3″ wood screws attach the left wall to the subfloor.
- Repeat for the right wall.
- Position the door-frame between the two walls. Adjust so all three are plumb and true. Then fasten the door frame to the side walls with three 4″ screws per side.
- Lastly, measure and cut three strips of OSB to finish the inner side of the door frame and the header gap above the door opening.
- Cut three pieces of polystyrene; same size as the OSB you just cut.
- Laminate the OSB/Foam to the door frame with acoustic sealant and secure with a couple of 2-1/4″ screws.
- Fill the wall cavities of the left/right walls with Roxol Safe-n-Sound insulation (DO NOT fill the air-way in the right-wall).

Completing the Walls



Drill holes for air exchange and wiring

- Using a 2-1/2″ hole saw, drill two or three holes – side by side – through the OSB/polystyrene inner wall in the upper right corner (3″ in from the right).
- Also drill through the studs that separate the lower, middle, and upper chambers of the air-maze.
- Using a 1″ bit, drill one hole in the bottom left of the left-side wall panel for other wiring (Mic, headphones, misc.)

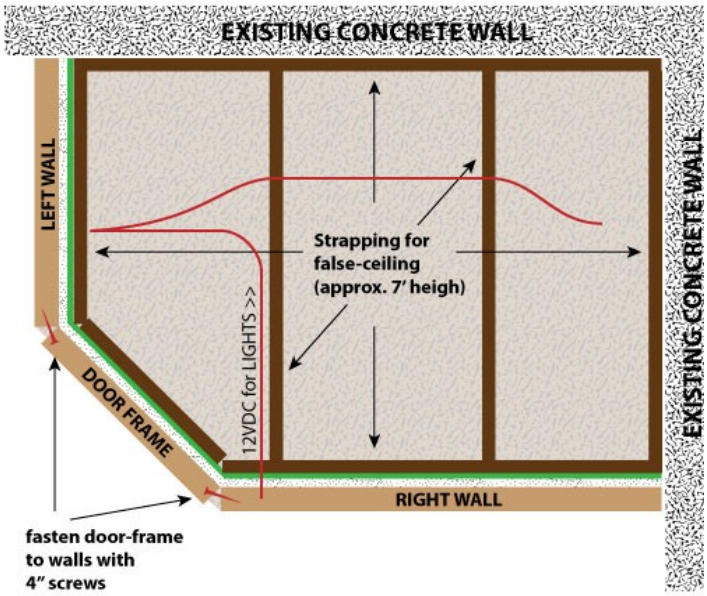
Wiring the wall

- Mount a 2-gang electrical box below and to the left of the window.
- Run 16AWG wire from the box:
    - up through the top of the wall for lights
    - down to the fan-box location.
    - down to the bottom (leave lots of extra for this lead – it goes to your 12VDC power supply).
- ALSO – not mentioned in the video (because I forgot), this is the time to run cables for your microphone, headphones, and anything else you might need inside the booth.
    - A 1-1/2″ hole should be big enough. Put this in a corner – where the cables won't pose a tripping hazard.

Install the drywall

- With the wiring complete and holes drilled, pack the left wall with insulation – especially around the cables to prevent sound leakage.
- Pack the right wall also – but DO NOT fill the ventilation maze. This remains empty for air-flow.
- Measure gypsum board to exactly match the left and right walls. Allow for a 3/4″ gap between the bottom edge and actual room-floor.
    - *This gap will be handy if you need to hide wire runs behind the baseboard.*
- Cut out openings for the window and switch box. Set the cut drywall panels aside.

- Apply a bead of acoustic sealant to the exterior face of all studs.
- Carefully align the cut panels to each wall (*remembering to lift them up 3/4″ off the floor*) and secure them to the studs with minimal drywall screws.
- With the drywall fixed in place, drill out the 1″ hole in the bottom left of the left wall to match the the position of the 1″ hole in the OSB.
- Drill out the 3-1/2″ hole in the bottom-right corner of the drywall to match the ventilation hole in the subfloor.

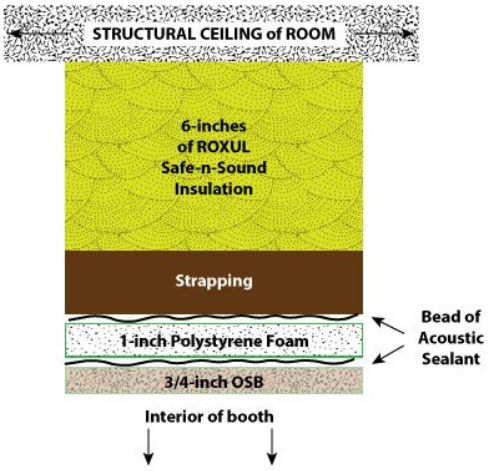


The Ceiling

The studs for the ceiling frame can be screwed directly to the walls. When the ceiling is complete, the booth will become very strong and rigid.

NOTE: You will need TWO people for this part.

- Inside the booth, affix studs horizontally at 84″ high around the inside of the booth.
- Cut and affix two studs as cross-supports (see “strapping” in the above diagram). This will ensure your ceiling doesn’t sag and the rigidity will help with sound quality.
- Position a double layer of sound-proof insulation above the frame.
- With the ceiling framed and insulated, run the 16AWG for the lights and tack in place.
- Cut a sheet of OSB precisely to fit for the booth ceiling.
- Cut an identical piece of Polystyrene Foam.
- Laminate the OSB/Foam with acoustic sealant.
- Drill 1/4″ holes and pull the 16AWG wiring through for the lights.
- Fasten the OSB/Foam ceiling panel in place with 3″ wood screws.



The Door Frame and Casing

The finished door and casing, trimmed out, will click closed with magnetic catches to create an almost air-tight seal. The door is constructed to snugly slide into the door casing. The tight seal is essential for good sound-damping.

The overall thickness of the door casing should be 5-7/8″ (5/8″ drywall + 3-1/2″ stud + 1″ Polystyrene + 3/4″ OSB)

- Start out with solid pine, 6″ wide x 3/4″ thick.
- Rip this to 5-7/8″ wide. Use this for the door casing: Unlike most door casings, this one will have a top, sides, and bottom/sill
- As you put this together you might notice a 2-3/8″ gap under the sill – this is because the door frame studs are only 3-1/2″ and the casing is 5-7/8″. Stepping on this will eventually cause the pine casing to split, so cut a leftover piece of stud to permanently slide in under the sill for support.
- Once the pine casing is secured to the studs, measure the width and height of the opening. Subtract 1/4″ from both measurements – these are the dimensions of the actual door.

The Door

- Write down the dimensions of the door as determined in the previous step – you've got some math to do…
- First, cut two 2×4 studs to the appropriate height – these are the left and right edges of the door.
- Next, rip a groove down the center of a one wide edge – one groove per stud. The groove should be 1/2″ deep x 3/4″ wide.
- Now, assuming your studs are 1-1/2″ thick, subtract 3″ from the width of the door (the width, as you have written down) – and cut two of these from a 2×4. These are the top and bottom edges of the door.

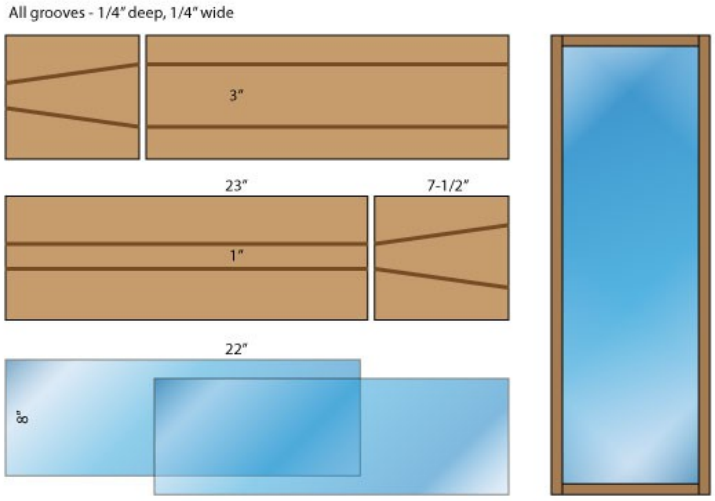
- Rip a groove down the center of these as well – one side on each.
- Subtract 2″ from the width and height as you have written down and cut a sheet of 3/4″ spruce plywood to these dimensions – this is the door panel.
- This rectangular plywood panel should fit snugly into the grooves along the top, bottom, left, and right door edges.
- DON'T screw/glue anything together yet… Check that everything is square and that the finished dimensions are exactly as you have written down. If anything is off, now is the time to correct it.
- If it's all good, disassemble – proceed by running a thin bead of construction adhesive in the four grooves. Reassemble, checking again for correct dimensions and right angles. Secure the four corners with 3″ wood screws.
- The panel, on both the front and the back, will be inset by 1-3/8″.
- Measure the width/height of the inset front panel and cut polystyrene foam to fit.
- Cut gypsum board to the same dimensions.
- Bond the polystyrene and gypsum board with acoustic sealant.
- Apply sealant to the surface of the front door panel. Press the polystyrene/gypsum board into place and secure with minimal 2″ drywall screws.
- Repeat for the back panel.
- The door can now be hung in the casing on hinges – position it flush with the exterior and swing outward.

The Door (Part 2)

- Once the door is hung, plane any sticky edges to minimum tolerance – try not to exceed 1/8″ gap on any side.
- Once planed and freely opening/closing without obstruction, apply closed-cell rubberized foam tape (weather strip) to the inside face of the door, as close to the edge as possible.
- Then, with the door closed flush, mark the position of door stops on the casing around all four edges.
- Install door stops – I ripped a 2×4 down to 1″x1″ for these – when the door closes, the foam tape should now rest snug against the stops. There should be no air gaps, nor should the tape be so compressed that the door "pops" open.
    - There is fine line here – it took me several attempts to find the sweet spot.
- Now, last step … using 3″ wide x 1/4″ solid wood trim (DON'T use MDF for this, it will warp) – measure, cut and fasten the wood trim to the front face of the door so there is a 1″ overlap all the way round.
- Apply a strip of closed-cell foam tape to this overlap, so when the door closes the foam tape creates a seal around the door.
    - Again, there should be no air gaps, but it should be bulky enough to prevent the door from staying closed.
    - NOTE: depending on your level of precision – or lack thereof, in my case – you might have to use two strips of foam-tape, one on each of the facing surfaces, to achieve a good seal … it will no doubt require some fussing/trial-and-error.
- Finally, with the door held closed, position and mount the magnetic catches. The door should now effortlessly "click" closed, held only by magnets, and have an airtight double-seal all the way round.

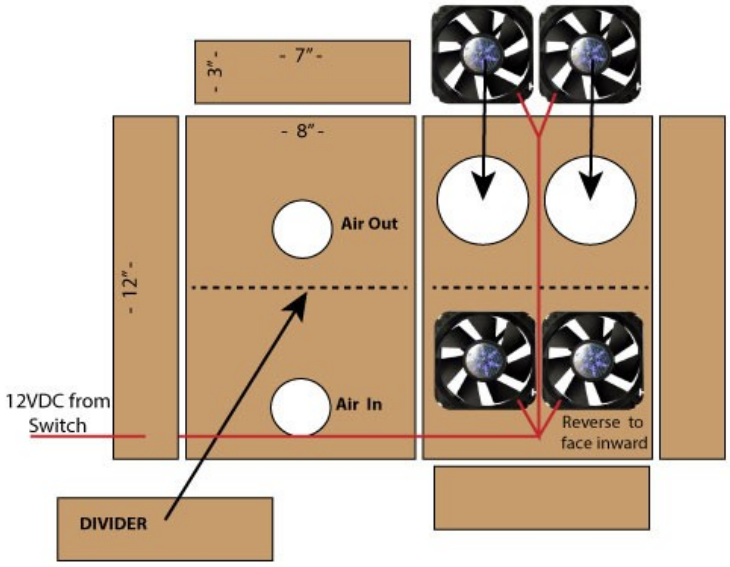
- OH MY GOD – YOU'RE TRAPPED! – 1/2 an hour ago would have been a good time to fashion a door handle from some scrap wood.

The Window



- Just like the door casing, the window is also 5-7/8″ deep and made of 3/4″ pine.
- Measure the width and height of the window opening – 23″ x 9″ in this example – these are outer dimensions of your window. It has to be a very tight fit, so there is no need to allow for a gap.
- The dimensions of the glass panes will be exactly 1″ shorter and narrower than the outer dimensions – so, 22″ x 8″ for this example.
- Give these measurements to your local glass shop – Ask for 1/4″ glass, like they use for glass shelves. *(My local shop – Sam's Auto Glass in North Sydney – charged $20 for both panes)*
- Using the outer measurements, cut four pieces of pine – the top, bottom, left and right sides.
- Rip two grooves, 1″ apart on center, 1/4″ deep and 1/4″ wide, along the length of one of the longer pieces.
- In the other long piece, rip two grooves 3″ apart on center, 1/4″ deep and 1/4″ wide.
- Clamp everything together and mark the spots where the four grooves in the long pieces intersect with the short pieces – four spots on the end of each piece.
    - Connect the dots as if you were making a "V" with a flat bottom on each short piece.
    - Remove from the clamps and rip grooves along these lines as well.
- Clamp together one long and two short pieces.
- Slide the two panes of glass all the way down into the "V" grooves – check to be sure the glass sits in the grooves of the long side. Join the 4th side and confirm that everything fits – *you might have to widen the grooves by a 1/16″ because of the angle of glass.*
- MEASURE AGAIN to MAKE SURE the finished assembly will fit in the window opening.
- I made the mistake of putting clear caulking in the grooves – DO NOT DO THIS.
- If it all fits – screw it together at the corners (drill pilot holes first to avoid splitting the wood), and slide the completed window into the window opening.
- You can now put clear caulking around the outer edges where the panes meet the pine frame.

The Fan Box



- Use plywood leftover from the door for this.
- Front and back pieces are both 8″ x 12″.
- The two sides are 3″ x 12″
- The top, bottom and divider are all 7″ x 3″
- The fan box will rest on the floor, so drill two 2-1/2″ holes in the back panel of the box, in exactly the same positions as the two air-holes on the booth (lower right corner of right wall). The holes in the back of the box have to line-up with the holes in the booth.
- Drill four 3″ holes in the front panel of the box – two across the middle of the upper half, two in the lower half.
- Drill a 1/4″ hole in the bottom center of the left panel.
- Drill a 1/4″ hole in the center of the divider.
- Assemble the box as shown in the diagram, using the divider to separate the upper and lower halves of the box.
- Run the 12VDC line form the switch box in through the 1/4″ hole in the side of the fan box.
    - marette or solder four leads here (parallel) – one for each fan.
    - Pull two leads out through the bottom fan holes.
    - Pull two leads up through the divider and out through the two top fan holes.
- Secure the box to the outside of the booth with construction adhesive (NOT screws) so the air holes line up.
- Connect the 12VDC to fans and mount the fans over the four holes –
    - Orient the top two fans to blow air OUT of the box
    - Reverse the the orientation of the bottom two so they blow air IN to the box.

12VCD Supply

- Check the output of the power supply that came with your LED lights.
- Measure the load for the four fans and two lights combined. Make sure this load doesn't exceed the max of the power supply. If it does, you'll need to source a power supply with more available current.
- Assuming you have enough juice, connect the 12VDC power supply to the lead coming down from the switch box.
- Might as well connect the switches now, while you're at it, because the lights are next …

Inside the Booth

- Connect and mount the two LED light strips to the ceiling.
- Lay the laminate floor as per the instructions on the box.

        - Drill two 2-1/2″ holes, side by side, through the floor into the air chamber at the end of the maze in the subfloor frame.
        -
- Finish trim as needed around the window, door, corners, and use cover plates to tidy-up the holes where cables enter the booth..
    - OPTIONAL: Instead of using the pre-milled trim, I ripped a couple of 2×4's and made my own 1-1/2″ trim.
- Apply the acoustic foam tiles to the ceiling, inside of door, sides, and back of booth
    - You only have 48 sq.ft. so you'll need to figure out how many squares go in each location.
- Build a script stand from of leftover wood. Mount it permanently to the front wall so it doesn't vibrate or rattle.
- Finally … FINALLY … give it all a coat of paint and crack the Dom Perignon because YOU … ARE … DONE !!!

Pass it on!

Please don't forget to share this page with your friends and colleagues who might benefit. Thanks.