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**iPhone Attachment For Stethoscope Recording**

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**Abstract**

With the ubiquity of smartphones and the rising technology of 3D printing, novel devices can be developed that leverage the “computer in your pocket” and rapid prototyping toward scientific, medical, engineering, and creative purposes. This paper describes such a device: a simple 3D-printed extension for Apple’s iPhone that allows the sound from a standard stethoscope to be recorded using the phone’s built-in microphone. 3D printing allows for easy sharing and updating of the attachment, for modification for other phones and devices capable of recording audio, and for fabrication of a durable device without need for an entire factory of expensive, heavy, and specialized machining tools. It is hoped that by releasing this device as an open source set of printable files that can be downloaded and reproduced cheaply, others can make use of these developments where access to more expensive or non-portable medical instruments are not available and without the cost usually associated with specialized medical equipment. Coupled with specialized smartphone software (“apps”), more sophisticated diagnostics may be possible on-site.

**Keywords**

iPhone, stethoscope, audio recording, 3D printing, STL, Shapeways, smartphone, app, sound, selective laser sintering, fused deposition modeling

**1. Introduction**

The following is in some ways more of a “how to” than a laboratory procedure; this is worth noting for two reasons. First, 3D printing handles much of the heavy lifting, creating the component that acts as interface between the iPhone and the stethoscope. Once printed the component requires minimal preparation for use. Second, I am a visual artist and this device is born out of my creative research. The stethoscope attachment was originally conceived as a device for making interesting, experimental audio recordings. The additional use as a medical instrument provides further evidence of something I believe strongly: that research in the arts can have practical and important applications in STEM fields.

**2. Materials**

1. Stethoscope head with fitting for standard 1/4” ID tubing
2. Standard stethoscope tubing (single lumen), 3/8” OD, 1/4” ID, at least 6” long (see Note 1)
3. Optional: Y-shaped tube fitting for simultaneously monitoring sound with standard stethoscope earpiece (see References)
4. 3D-printed iPhone attachment
5. iPhone generation 4, 4S, or 5
6. Sound recording app for iPhone such as pre-installed “Voice Recorder”

**3. Methods**

This section describes 3D printing, assembly, and use of the stethoscope attachment. The first of these instructions describe printing the attachment using the service Shapeways; if a 3D printer is available locally the attachment can be printed using a variety of alternative methods outlined in section 3.1.b (see Notes for possible issues and further suggestions).

**3.1.a. Printing The Attachment Using Shapeways’ 3D Printing Service**

1. Visit the following link to order a 3D-printed version of the stethoscope attachment: <http://shpws.me/oQUX>
2. Choose a material color from the “Material Options” dropdown menu – default is white (see Note 2)
3. Click the “Buy Now” button to order the printed model in the material specified (see Note 3)

**3.1.b. Alternatively, Print Using a Local 3D Printer**

1. Visit the project’s GitHub repository: <https://github.com/jeffthompson/iPhoneStethoscopeAttachment>
2. Download the necessary files by clicking the “Download ZIP” button in the right sidebar. This includes the printable stereolithography (STL) files, as well as supporting documents and sample recordings.
3. Print using a hard material such as ABS or PLA plastic at 100% infill; other settings will depend on model of 3D printer (see Note 4)
4. Clean and sand/file printed model as necessary for a smooth finish

**3.2. Prepare Stethoscope Tubing**

1. Cut the stethoscope tubing using a sharp knife or scissors below the fork to form a single tube. Length is variable but 15” (38cm) is comfortable without being too long.
2. If desired, an optional Y-shaped splitter can be used to simultaneously monitor the sound through normal stethoscope earpieces. If doing so, another two more lengths of tubing are required.

**3.3. Assemble the Attachment**

1. Slide one end of the stethoscope tubing over the barb in the stethoscope head until secure
2. Insert the other end of the stethoscope tubing over the barb at the bottom of the 3D printed attachment; the tubing should fit tightly but can be carefully removed (see Note 5)
3. Slide the 3D printed attachment over the bottom of the phone; the half-circle cutout in the attachment should align with the “home” button on the iPhone; slide in until the bottom of the phone hits the bottom of the 3D printed attachment (see Note 6)

**3.4. Test and Record**

1. Turn on the phone and launch an audio recording app like Voice Recorder (see Note 7)
2. Press record and test the stethoscope; depending on your app’s sensitivity settings, loud sounds should be very clearly picked up by the microphone (see Note 8)

**4. Notes**

1. The design of the attachment’s barb allows for some variation in the dimensions of the tubing: any tube approximately 1/4" inside diameter will fit.
2. Shapeways’ “Strong and Flexible” material is laser-sintered nylon plastic, resulting in prints that are very strong with some flexibility. Printed parts can be easily cleaned, are dishwasher safe, and are heatproof to 80C/176F. See the following link for more information: <https://www.shapeways.com/materials/strong-flexible>
3. While Shapeways offers a variety of other materials for printing, if you would like to experiment with different materials please see the GitHub link to download and print your own (see Note 3)
4. Depending on your printer’s method and output material, specific settings may be required for a high-quality and durable print. For Fused Deposition Modeling (FDM) printing like the MakerBot, shrinkage may require re-engineering the model based on trial and error. Such considerations are not needed for laser-sintered nylon. It is suggested that FDM printers are set to 100% infill with at least 2-3 shells for a durable print.
5. This design, with the barb extending from the bottom of the 3D printed attachment, allows for the strongest connection with the tubing. An alternative design, available on the GitHub repository, simply has a hole in the bottom of the attachment for inserting the tubing. This is less sturdy but very easy to disassemble and put back together for cleaning, storage, or customization.
6. While every effort has been taken to avoid damage to the iPhone, it should be noted that the 3D printed attachment is pressure-fit to the phone’s body. Attachments printed using Shapeways’ laser-sintered nylon and MakerBot-printed ABS plastic both left no scratches on the phone’s surface, even at a tight fit and many installations/removals. However, use at your own risk.
7. Apple’s built-in Voice Recorder app is quite adequate for basic recording, but offers little manual control. Voice Record Pro (free, <https://itunes.apple.com/us/app/voice-record-pro/id546983235?mt=8>) offers manual quality adjustment (the “high quality” setting is 44.1kHz/16-bit at a bitrate of 128,000) but is limited to the AAC/MP4/M4A compressed audio formats. Audio Memos ($9.99 USD with in-app upgrades, <https://itunes.apple.com/us/app/audio-memos-pro/id290160980?mt=8>) has a large level meter and allows recording in the uncompressed WAV format. Both apps can be set to auto-upload to Dropbox and similar cloud services.
8. Better-quality audio recording apps may have adjustable gain for microphone input. If audio level problems persist, check that the stethoscope tubing and barb of the 3D printed attachment to the iPhone microphone are not blocked.

**5. References**

In the interest of accessibility and cost-savings, some alternatives to purchasing parts from medical supply companies are suggested here:

1. “UV-Resistant Black PVC Tubing” from McMaster Carr  
   <http://www.mcmaster.com/#5231k83/=oainxw>
2. “Sanitary White PVDF Barbed Tube Fitting” from McMaster Carr  
   <http://www.mcmaster.com/#53055k155/=oailx5>

**FIGURE CAPTIONS**

*Note: figures can be placed anywhere in the text, though a large version of figure #1 at the start of the chapter would be ideal. Thank you!*

Fig. 1. The completed iPhone stethoscope attachment, printed using laser-sintered nylon.

Fig. 2. A CAD rendering of the 3D printed attachment, which slides tightly onto the bottom of the iPhone. Note how the sound from the stethoscope’s tube is funneled directly into the phone’s built-in microphone. Shapes like this are difficult to manufacture, making 3D printing is an ideal solution in such cases.

Fig. 3. Waveform of a recording of a human heartbeat with a low-pass filter applied; while the low-frequency audio may be difficult to hear, the beat is clearly visible

Fig. 4. Frequency analysis of a recording of a human heartbeat with no filter applied. While the noise floor for the iPhone’s built-in microphone is rather high, the low-frequency heartbeat is still clearly visible.