Created in COMSOL Multiphysics 6.2

# Type 4.3 Ear Simulator

## Introduction

This model is of the P.57 Type 4.3 Full-Band Ear Simulator. The model includes the geometry of the ear canal as well as the pinna defined in the ITU-T P.57 standard. The model also includes interpolation data for an ear drum impedance ensuring correct acoustic properties of the ear. The model tries to fulfill the geometry and acoustic requirements defined in the standard. It is not a model of a particular, commercially available, ear simulator.

## Model Definition

This model imports a geometry representation of the ear canal (Figure 1) as well as the combined pinna and ear canal (Figure 2) that is defined in the ITU-T P.57 standard, Ref. 1. To fulfill the acoustic requirements specified in the ITU-T P.57 standard, the eardrum impedance presented in Nielsen and Jensen, 2022 (Ref. 2) is imported as an interpolation function and used. Some details about the construction of the geometry are presented in Ref. 2.

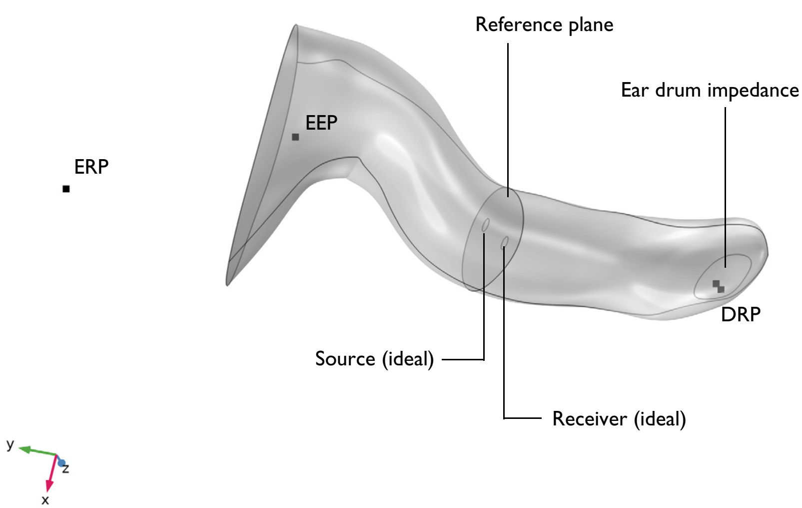



*Figure 1: Geometry of the ear canal including reference plane.*

A typical use case, where an in-ear device is tested (for example, a hearing aid) in the artificial ear, is presented in Nielsen and Jensen, 2023 (Ref. 3). In the reference, a comparison between measurements (using a commercially available ear simulator) and simulations using the present ear geometry and impedance is carried out. The presented results show good correlation.

In the first model component (**Component 1**), the ear canal geometry shown in Figure 1 is imported. The image shows the ear reference point (ERP, here outside of the geometry), the ear entrance point (EEP), and the eardrum reference point (EDP). The image also shows the reference plane which is used when defining the transfer impedance of the system. A simulation, mimicking a typical measurement setup to compute the transfer impedance from the reference plane to the eardrum, is set up. The transfer impedance (absolute value of) is the acoustic characteristic defined in the ITU-T P.57 standard. The resulting absolute valued transfer impedance (times the frequency) $|Z \cdot f|$ is depicted in the results section in Figure 4. A comparison between a simulated transfer impedance and the standard is shown in Ref. 1. The location of an ideal source and an ideal receiver (corresponding to probes tubes in a typical measurement) is also depicted in Figure 1.

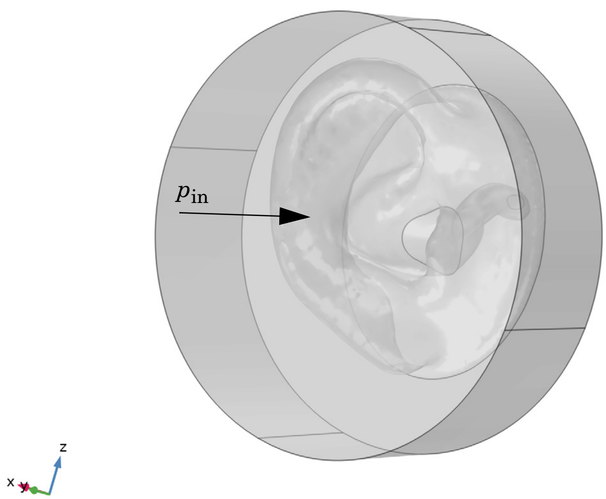



*Figure 2: Geometry of the combined ear canal and pinna, including an exterior cylindrical air domain.*

In the second model component (**Component 2**), the combined ear canal and pinna shown in Figure 2 is imported. The geometry also includes an exterior cylindrical air domain. Using this geometry, the open ear response to a normally incident plane wave $p_{in}$ is simulated (see the arrow in Figure 2). The open boundaries of the cylindrical air domain are modeled using the **Perfectly Matched Boundary** condition.

## *Results and Discussion*

The pressure and sound pressure level (SPL) distributions in the ear canal (from the reference plane to the ear drum) evaluated at 20 kHz are depicted in Figure 3. The absolute value of the transfer impedance (times the frequency) $|Z{\cdot}f|$ is depicted in Figure 4. This curve represents the acoustic signature of the ear simulator described in the ITU-T P.57 standard.

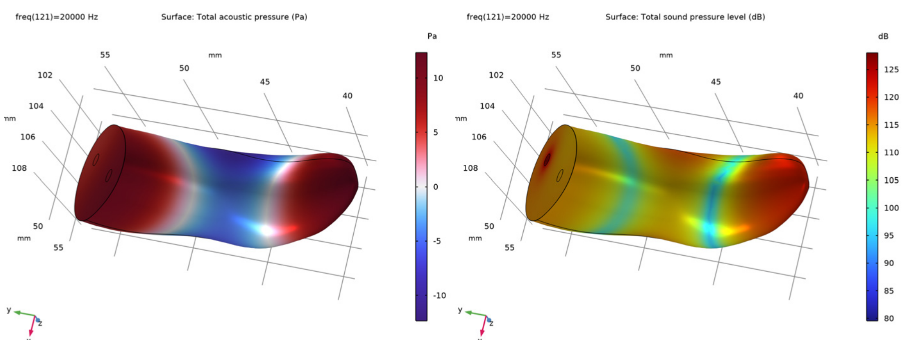



*Figure 3: Pressure (left) and SPL (right) distribution in the ear canal at 20 kHz.*

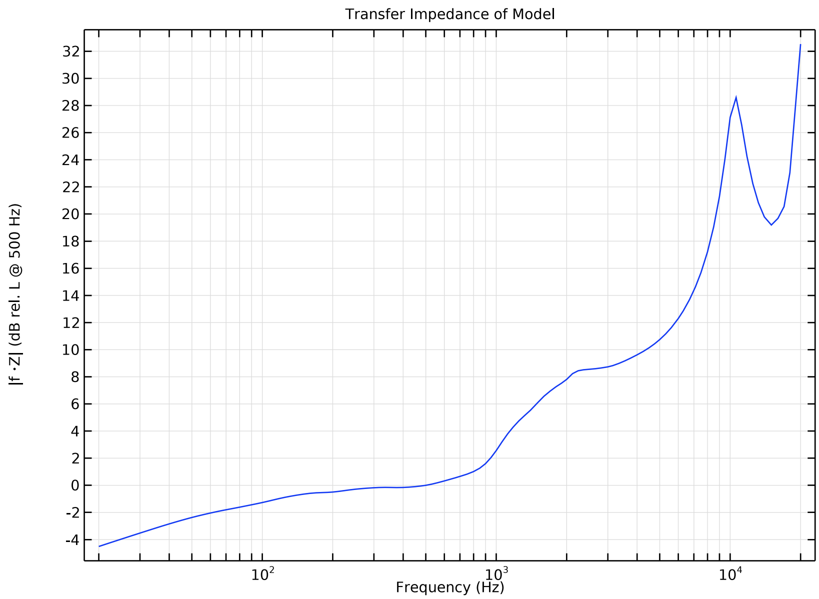



*Figure 4: Absolute value of the transfer impedance (times frequency) as function of frequency. Computed from the reference plane to the ear drum.*

The total pressure (incident plus scattered) and the total SPL at the surface of the pinna for the setup described in Figure 2 is depicted in Figure 5. The open ear response as a function of frequency is depicted in Figure 6; here specifically showing the sound pressure level at the ear drum.

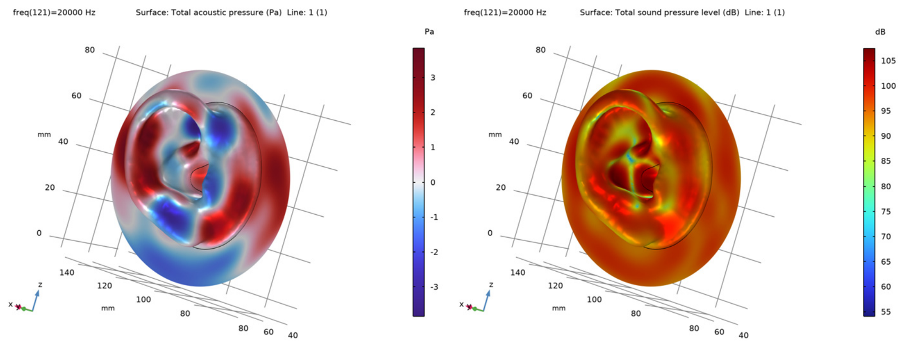



*Figure 5: Total pressure (left) and SPL (right) distribution on the surface of the ear at 20 kHz.*

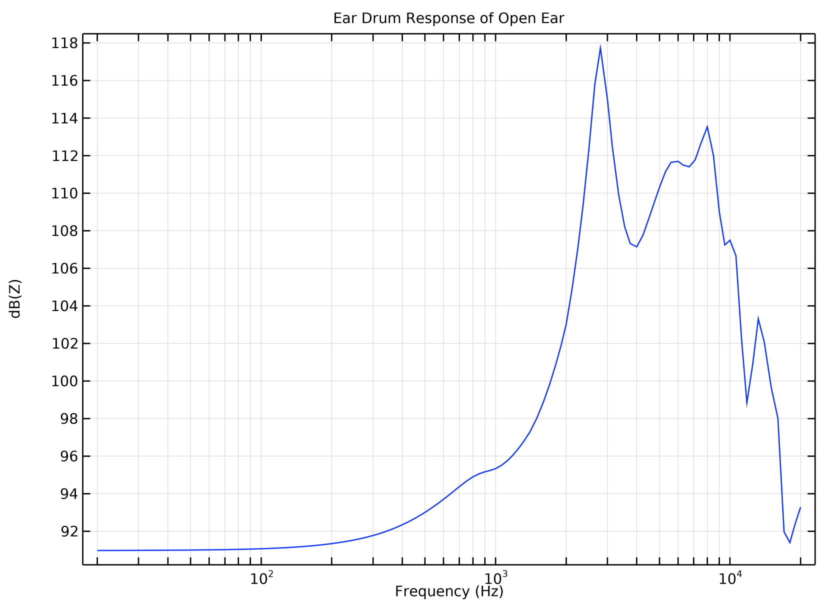



*Figure 6: Ear drum response of the open ear as function of frequency.*

## References

1. ITU-T Recommendation P.57: Artificial Ears. 2021.

2. L.B. Nielsen and M. Herring Jensen, “The Digital Twin of a New and Standardized Fullband Ear Simulator,” DAGA 2022.

3. L.B. Nielsen and M. Herring Jensen, “Simulation and physical testing using standardized ear simulator,” DAGA 2023.

**Application Library path:** `Acoustics_Module/Tutorials,_Thermoviscous_Acoustics/type_43_ear_simulator`

## *Modeling Instructions*

From the **File** menu, choose **New**.

### NEW

In the **New** window, click **Model Wizard**.

### MODEL WIZARD

1 In the **Model Wizard** window, click **3D**.

2 In the **Select Physics** tree, select **Acoustics>Pressure Acoustics>Pressure Acoustics, Frequency Domain (acpr)**.

3 Click **Add**.

4 Click **Study**.

5 In the **Select Study** tree, select **General Studies>Frequency Domain**.

6 Click **Done**.

### GLOBAL DEFINITIONS

*Parameters 1*

1 In the **Model Builder** window, under **Global Definitions** click **Parameters 1**.

2 In the **Settings** window for **Parameters**, locate the **Parameters** section.

3 In the table, enter the following settings:

| Name | Expression | Value | Description |
|---|---|---|---|
| vn | 1[m/s] | 1 m/s | Source velocity |

*Interpolation 1 (int1)*

1 In the **Home** toolbar, click f(X) **Functions** and choose **Global>Interpolation**.

2 In the **Settings** window for **Interpolation**, locate the **Definition** section.

3 From the **Data source** list, choose **File**.

4 Click **Browse**.

5 Browse to the model's Application Libraries folder and double-click the file `type_43_ear_simulator_impedance.txt`.

6 In the **Number of arguments** text field, type `1`.

7 Find the **Functions** subsection. In the table, enter the following settings:

| Function name | Position in file |
| --- | --- |
| absZ | 1 |
| argZ | 2 |

8 Locate the **Interpolation and Extrapolation** section. From the **Interpolation** list, choose **Piecewise cubic**.

9 From the **Extrapolation** list, choose **Linear**.

10 Locate the **Units** section. In the **Function** table, enter the following settings:

| Function | Unit |
| --- | --- |
| absZ | kg/(m^2*s) |
| argZ | rad |

11 In the **Argument** table, enter the following settings:

| Argument | Unit |
| --- | --- |
| Column 1 | 1 |

## GEOMETRY 1

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Geometry 1**.

2 In the **Settings** window for **Geometry**, locate the **Units** section.

3 From the **Length unit** list, choose **mm**.

4 Locate the **Advanced** section. From the **Geometry representation** list, choose **CAD kernel**.

### *Import 1 (imp1)*

1 In the **Home** toolbar, click **Import**.

2 In the **Settings** window for **Import**, locate the **Import** section.

3 Click **Browse**.

**4** Browse to the model's Application Libraries folder and double-click the file `type_43_ear_simulator_ear_canal.mphbin`.

**5** Click **Import**.

**6** In the **Home** toolbar, click **Build All**.

## ADD MATERIAL

**1** In the **Home** toolbar, click **Add Material** to open the **Add Material** window.

**2** Go to the **Add Material** window.

**3** In the tree, select **Built-in>Air**.

**4** Click **Add to Component** in the window toolbar.

**5** In the **Home** toolbar, click **Add Material** to close the **Add Material** window.

## DEFINITIONS

### *Variables 1*

**1** In the **Home** toolbar, click **Variables** and choose **Local Variables**.

**2** In the **Settings** window for **Variables**, locate the **Variables** section.

**3** In the table, enter the following settings:

| Name | Expression | Unit | Description |
|---|---|---|---|
| `Ztrans` | `aveop1(acpr.p_t)` | | |
| `Zin` | `aveop2(acpr.p_t)/intop1(vn)` | | |

### *Source*

**1** In the **Definitions** toolbar, click **Explicit**.

**2** In the **Settings** window for **Explicit**, type `Source` in the **Label** text field.

**3** Locate the **Input Entities** section. From the **Geometric entity level** list, choose **Boundary**.

**4** Click **Paste Selection**.

**5** In the **Paste Selection** dialog box, type `8` in the **Selection** text field.

**6** Click **OK**.

### *Probe Microphone*

**1** In the **Definitions** toolbar, click **Explicit**.

**2** In the **Settings** window for **Explicit**, type `Probe Microphone` in the **Label** text field.

**3** Locate the **Input Entities** section. From the **Geometric entity level** list, choose **Boundary**.

**4** Click **Paste Selection**.

5 In the **Paste Selection** dialog box, type `9` in the **Selection** text field.

6 Click **OK**.

*Ear Drum*

1 In the **Definitions** toolbar, click **Explicit**.

2 In the **Settings** window for **Explicit**, type `Ear Drum` in the **Label** text field.

3 Locate the **Input Entities** section. From the **Geometric entity level** list, choose **Boundary**.

4 Click **Paste Selection**.

5 In the **Paste Selection** dialog box, type `7` in the **Selection** text field.

6 Click **OK**.

*Integration 1 (intop1)*

1 In the **Definitions** toolbar, click **Nonlocal Couplings** and choose **Integration**.

2 In the **Settings** window for **Integration**, locate the **Source Selection** section.

3 From the **Geometric entity level** list, choose **Boundary**.

4 From the **Selection** list, choose **Source**.

*Average 1 (aveop1)*

1 In the **Definitions** toolbar, click **Nonlocal Couplings** and choose **Average**.

2 In the **Settings** window for **Average**, locate the **Source Selection** section.

3 From the **Geometric entity level** list, choose **Boundary**.

4 From the **Selection** list, choose **Ear Drum**.

*Average 2 (aveop2)*

1 In the **Definitions** toolbar, click **Nonlocal Couplings** and choose **Average**.

2 In the **Settings** window for **Average**, locate the **Source Selection** section.

3 From the **Geometric entity level** list, choose **Boundary**.

4 From the **Selection** list, choose **Probe Microphone**.

### PRESSURE ACOUSTICS, FREQUENCY DOMAIN (ACPR)

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Pressure Acoustics, Frequency Domain (acpr)**.

2 In the **Settings** window for **Pressure Acoustics, Frequency Domain**, locate the **Domain Selection** section.

3 Click **Clear Selection**.

4 Click **Paste Selection**.

5 In the **Paste Selection** dialog box, type `2` in the **Selection** text field.

6 Click **OK**.

7 In the **Settings** window for **Pressure Acoustics, Frequency Domain**, locate the **Typical Wave Speed for Perfectly Matched Layers** section.

8 In the $c_{\mathrm{ref}}$ text field, type `343[m/s]`.

### *Impedance 1*

1 In the **Physics** toolbar, click **Boundaries** and choose **Impedance**.

2 In the **Settings** window for **Impedance**, locate the **Boundary Selection** section.

3 From the **Selection** list, choose **Ear Drum**.

4 Locate the **Impedance** section. In the $Z_{\mathrm{n}}$ text field, type `absZ(log10(freq[1/Hz]))*exp(i*argZ(log10(freq[1/Hz])))`.

### *Normal Velocity 1*

1 In the **Physics** toolbar, click **Boundaries** and choose **Normal Velocity**.

2 In the **Settings** window for **Normal Velocity**, locate the **Boundary Selection** section.

3 From the **Selection** list, choose **Source**.

4 Locate the **Normal Velocity** section. In the $v_n$ text field, type `vn`.

### *Thermoviscous Boundary Layer Impedance 1*

1 In the **Physics** toolbar, click **Boundaries** and choose **Thermoviscous Boundary Layer Impedance**.

2 In the **Settings** window for **Thermoviscous Boundary Layer Impedance**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog box, type `4,5` in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Thermoviscous Boundary Layer Impedance**, locate the **Fluid Properties** section.

7 From the **Fluid material** list, choose **Air (mat1)**.

## MESH

Proceed and generate the mesh using the **Physics-controlled mesh** functionality. The frequency controlling the maximum element size is per default taken **From study**. Set the desired **Frequencies** in the study step. In general, 5 to 6 second-order elements per wavelength are needed to resolve the waves. For more details, see *Meshing (Resolving the*

*Waves)* in the *Acoustics Module User's Guide*. In this model, use the default **Automatic** option, which gives 5 elements per wavelength.

### ADD COMPONENT

Right-click **Thermoviscous Boundary Layer Impedance 1** and choose **Add Component>3D**.

### GEOMETRY 2

1. In the **Settings** window for **Geometry**, locate the **Units** section.
2. From the **Length unit** list, choose **mm**.

#### *Import 1 (imp1)*

1. In the **Home** toolbar, click **Import**.
2. In the **Settings** window for **Import**, locate the **Import** section.
3. Click **Browse**.
4. Browse to the model's Application Libraries folder and double-click the file `type_43_ear_simulator_full_ear.mphbin`.
5. Click **Import**.
6. In the **Home** toolbar, click **Build All**.

### ADD MATERIAL FROM LIBRARY

In the **Home** toolbar, click **Windows** and choose **Add Material from Library**.

### ADD MATERIAL

1. Go to the **Add Material** window.
2. In the tree, select **Built-in>Air**.
3. Click **Add to Component** in the window toolbar.
4. In the **Home** toolbar, click **Add Material** to close the **Add Material** window.

### DEFINITIONS (COMP2)

#### *Ear Drum*

1. In the **Definitions** toolbar, click **Explicit**.
2. In the **Settings** window for **Explicit**, type `Ear Drum` in the **Label** text field.
3. Locate the **Input Entities** section. From the **Geometric entity level** list, choose **Boundary**.
4. Click **Paste Selection**.
5. In the **Paste Selection** dialog box, type `8` in the **Selection** text field.
6. Click **OK**.

## ADD PHYSICS

1 In the **Home** toolbar, click **Add Physics** to open the **Add Physics** window.

2 Go to the **Add Physics** window.

3 In the tree, select **Acoustics>Pressure Acoustics>Pressure Acoustics, Frequency Domain (acpr)**.

4 Click **Add to Component 2** in the window toolbar.

5 In the **Home** toolbar, click **Add Physics** to close the **Add Physics** window.

## PRESSURE ACOUSTICS, FREQUENCY DOMAIN 2 (ACPR2)

### *Thermoviscous Boundary Layer Impedance 1*

1 Right-click **Component 2 (comp2)>Pressure Acoustics, Frequency Domain 2 (acpr2)** and choose **Thermoviscous Boundary Layer Impedance**.

2 In the **Settings** window for **Thermoviscous Boundary Layer Impedance**, locate the **Boundary Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog box, type 6 in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Thermoviscous Boundary Layer Impedance**, locate the **Fluid Properties** section.

7 From the **Fluid material** list, choose **Air (mat2)**.

### *Background Pressure Field 1*

1 In the **Physics** toolbar, click **Domains** and choose **Background Pressure Field**.

2 In the **Settings** window for **Background Pressure Field**, locate the **Domain Selection** section.

3 Click **Paste Selection**.

4 In the **Paste Selection** dialog box, type 1 in the **Selection** text field.

5 Click **OK**.

6 In the **Settings** window for **Background Pressure Field**, locate the **Background Pressure Field** section.

7 In the $p_0$ text field, type 1.

8 From the $c$ list, choose **From material**.

**9** Specify the $\mathbf{e}_k$ vector as

| | |
|---|---|
| 0 | x |
| -1 | y |
| 0 | z |

*Perfectly Matched Boundary 1*

1. In the **Physics** toolbar, click **Boundaries** and choose **Perfectly Matched Boundary**.
2. In the **Settings** window for **Perfectly Matched Boundary**, locate the **Boundary Selection** section.
3. Click **Paste Selection**.
4. In the **Paste Selection** dialog box, type `1,2,4,7,9` in the **Selection** text field.
5. Click **OK**.
6. In the **Settings** window for **Perfectly Matched Boundary**, locate the **Geometry** section.
7. Specify the $\mathbf{r}_0$ vector as

| | |
|---|---|
| 110.0[mm] | x |
| 67.6[mm] | y |
| 40.7[mm] | z |

*Impedance 1*

1. In the **Physics** toolbar, click **Boundaries** and choose **Impedance**.
2. In the **Settings** window for **Impedance**, locate the **Boundary Selection** section.
3. From the **Selection** list, choose **Ear Drum**.
4. Locate the **Impedance** section. In the $Z_n$ text field, type `absZ(log10(freq[1/Hz]))*exp(i*argZ(log10(freq[1/Hz])))`.

## MESH

Proceed and generate the mesh using the **Physics-controlled mesh** functionality. In this component, use again the default **Automatic** option, which gives 5 elements per wavelength.

## STUDY 1 - EAR CANAL

1. In the **Model Builder** window, click **Study 1**.
2. In the **Settings** window for **Study**, type `Study 1 - Ear Canal` in the **Label** text field.

*Step 1: Frequency Domain*

1 In the **Model Builder** window, under **Study 1 - Ear Canal** click **Step 1: Frequency Domain**.

2 In the **Settings** window for **Frequency Domain**, locate the **Study Settings** section.

3 Click **Range**.

4 In the **Range** dialog box, choose **ISO preferred frequencies** from the **Entry method** list.

5 In the **Start frequency** text field, type `20`.

6 In the **Stop frequency** text field, type `20000`.

7 From the **Interval** list, choose **1/12 octave**.

8 Click **Add**.

9 In the **Settings** window for **Frequency Domain**, locate the **Physics and Variables Selection** section.

10 In the table, enter the following settings:

| Physics interface | Solve for | Equation form |
|---|---|---|
| Pressure Acoustics, Frequency Domain (acpr) | √ | Automatic (Frequency domain) |
| Pressure Acoustics, Frequency Domain 2 (acpr2) | | Automatic (Frequency domain) |

*Solution 1 (sol1)*

In the **Study** toolbar, click **Show Default Solver**.

### ADD STUDY

1 In the **Study** toolbar, click **Add Study** to open the **Add Study** window.

2 Go to the **Add Study** window.

3 Find the **Studies** subsection. In the **Select Study** tree, select **General Studies> Frequency Domain**.

4 Click **Add Study** in the window toolbar.

5 In the **Study** toolbar, click **Add Study** to close the **Add Study** window.

### STUDY 2 - FULL EAR

1 In the **Model Builder** window, click **Study 2**.

2 In the **Settings** window for **Study**, type `Study 2 - Full Ear` in the **Label** text field.

*Step 1: Frequency Domain*

1 In the **Model Builder** window, under **Study 2 - Full Ear** click **Step 1: Frequency Domain**.

2 In the **Settings** window for **Frequency Domain**, locate the **Study Settings** section.

3 Click **Range**.

4 In the **Range** dialog box, choose **ISO preferred frequencies** from the **Entry method** list.

5 In the **Start frequency** text field, type 20.

6 In the **Stop frequency** text field, type 20000.

7 From the **Interval** list, choose **1/12 octave**.

8 Click **Add**.

9 In the **Settings** window for **Frequency Domain**, locate the **Physics and Variables Selection** section.

10 In the table, enter the following settings:

| Physics interface | Solve for | Equation form |
|---|---|---|
| Pressure Acoustics, Frequency Domain (acpr) | | Automatic (Frequency domain) |
| Pressure Acoustics, Frequency Domain 2 (acpr2) | √ | Automatic (Frequency domain) |

*Solution 2 (sol2)*

In the **Study** toolbar, click **Show Default Solver**.

### STUDY 1 - EAR CANAL

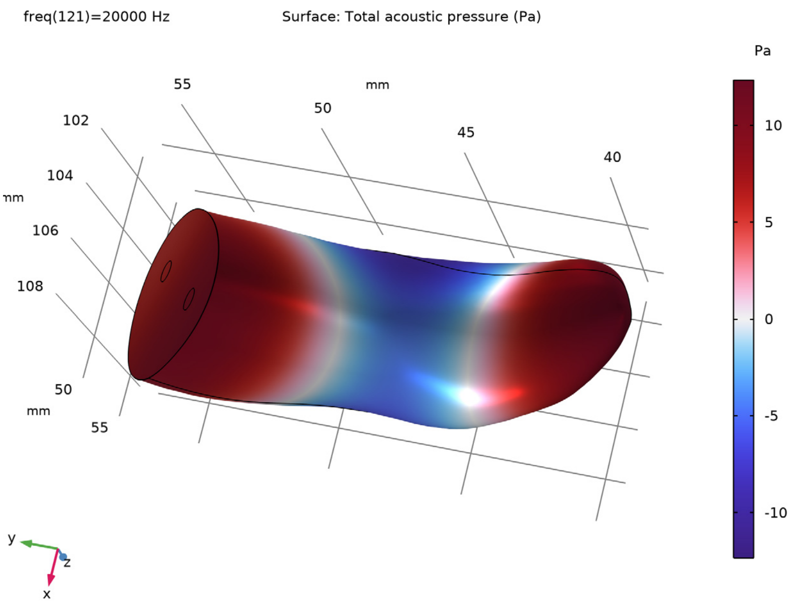
Click **Compute**.

## RESULTS

### *Acoustic Pressure (acpr)*

**1** In the **Acoustic Pressure (acpr)** toolbar, click **Plot**.

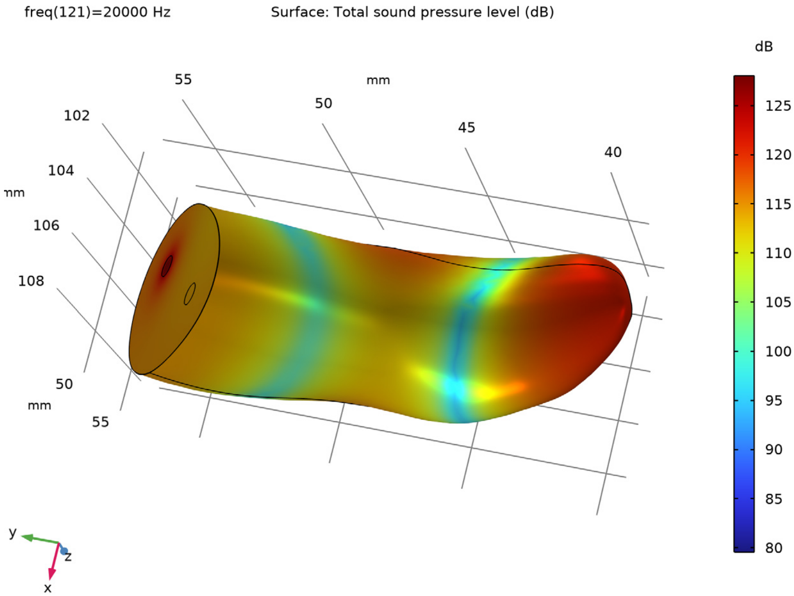
The acoustic pressure for the ear canal should look like the following figure:




### *Sound Pressure Level (acpr)*

**1** In the **Model Builder** window, click **Sound Pressure Level (acpr)**.

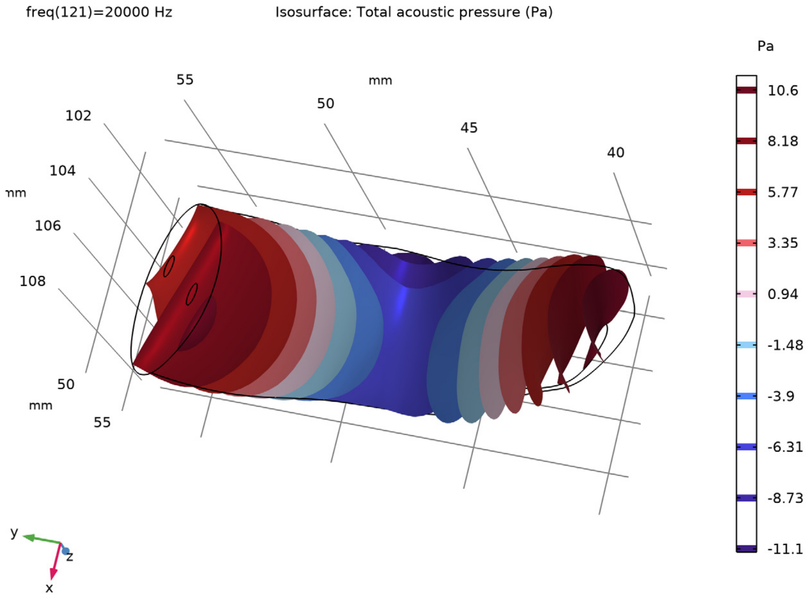
**2** In the **Sound Pressure Level (acpr)** toolbar, click **Plot**.




*Acoustic Pressure, Isosurfaces (acpr)*

**1** In the **Model Builder** window, click **Acoustic Pressure, Isosurfaces (acpr)**.

**2** In the **Acoustic Pressure, Isosurfaces (acpr)** toolbar, click **Plot**.




*Transfer Impedance of Model*

**1** In the **Home** toolbar, click **Add Plot Group** and choose **1D Plot Group**.

**2** In the **Settings** window for **1D Plot Group**, click to expand the **Title** section.

**3** From the **Title type** list, choose **Label**.

**4** In the **Label** text field, type `Transfer Impedance of Model`.

**5** Locate the **Plot Settings** section.

**6** Select the **x-axis label** check box. In the associated text field, type `Frequency (Hz)`.

**7** Select the **y-axis label** check box. In the associated text field, type `|f \cdot Z| (dB rel. L @ 500 Hz)`.

**8** Locate the **Axis** section. Select the **x-axis log scale** check box.

*Global 1*

**1** In the **Transfer Impedance of Model** toolbar, click **Global**.

**2** In the **Settings** window for **Global**, locate the **y-Axis Data** section.

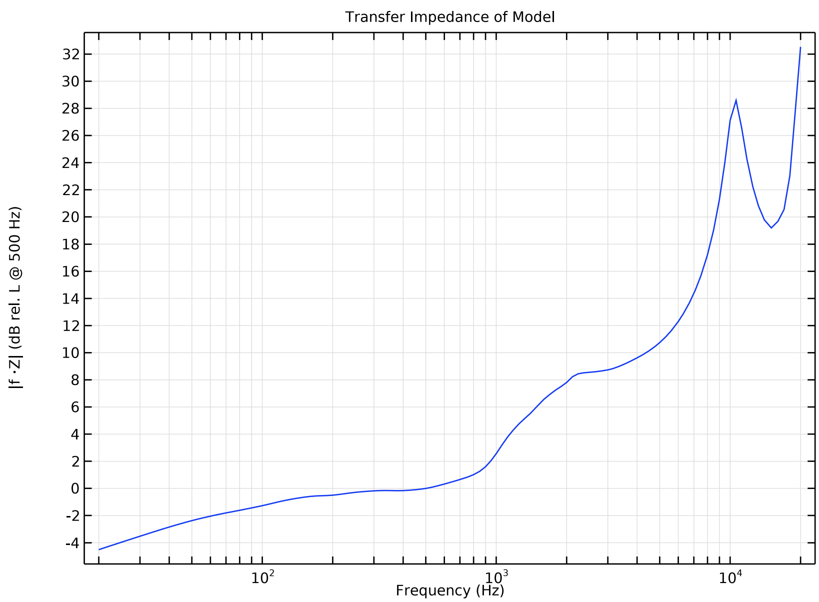
**3** In the table, enter the following settings:

| Expression | Unit | Description |
|---|---|---|
| `20*log10(freq*abs(Ztrans))-withsol('sol1',20*log10(freq*abs(Ztrans)),setval(freq,500))` | | `Model` |

**4** Click to expand the **Legends** section. Clear the **Show legends** check box.

**5** In the **Transfer Impedance of Model** toolbar, click **Plot**.

The simulated transfer impedance of the ear canal geometry should look like the following figure:




### STUDY 2 - FULL EAR

**1** In the **Home** toolbar, click **Compute**.

Next, delete the `Ear Canal/Solution 1 (2) (sol1)` and the `Study 2 - Full Ear/Solution 2 (3) (sol2)`. In theory, the components could be coupled in the studies but in this model they are not. Therefore, there is no need to have both solutions for each study.

**RESULTS**

*Study 1 - Ear Canal/Solution 1 (2) (sol1)*

1 In the **Model Builder** window, expand the **Results>Datasets** node.

2 Right-click **Results>Datasets>Study 1 - Ear Canal/Solution 1 (2) (sol1)** and choose **Delete**.

*Study 2 - Full Ear/Solution 2 (3) (sol2)*

In the **Model Builder** window, under **Results>Datasets** right-click **Study 2 - Full Ear/ Solution 2 (3) (sol2)** and choose **Delete**.

*Acoustic Pressure (acpr2)*

1 In the **Model Builder** window, under **Results** click **Acoustic Pressure (acpr2)**.

2 In the **Settings** window for **3D Plot Group**, locate the **Plot Settings** section.

3 Clear the **Plot dataset edges** check box.

*Selection 1*

1 In the **Model Builder** window, expand the **Acoustic Pressure (acpr2)** node.

2 Right-click **Surface 1** and choose **Selection**.

3 Select Boundaries 3, 5, 6, and 8 only.

*Line 1*

1 In the **Model Builder** window, right-click **Acoustic Pressure (acpr2)** and choose **Line**.

2 In the **Settings** window for **Line**, locate the **Expression** section.

3 In the **Expression** text field, type 1.

4 Locate the **Coloring and Style** section. From the **Coloring** list, choose **Uniform**.

5 From the **Color** list, choose **Black**.

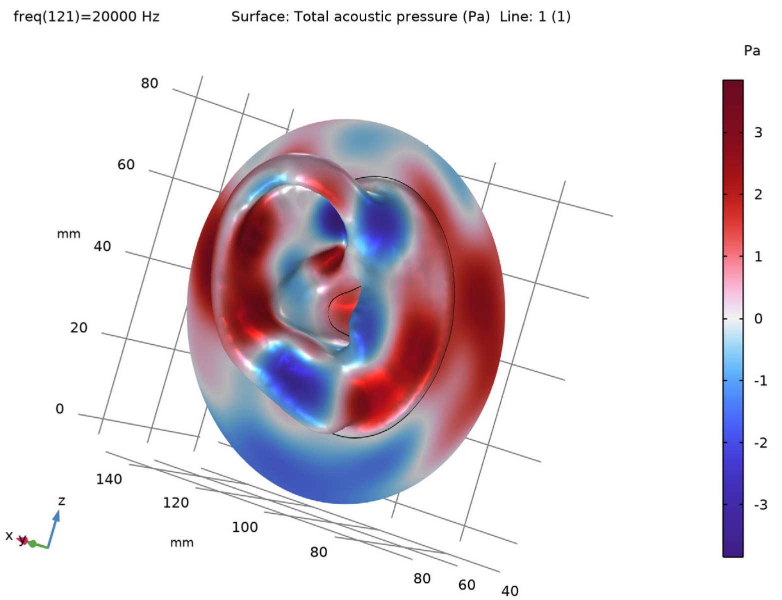
*Selection 1*

1 Right-click **Line 1** and choose **Selection**.

2 Select Edges 6–9, 13, and 14 only.

3 In the **Acoustic Pressure (acpr2)** toolbar, click **Plot**.

The acoustic pressure of the pinna and ear canal system should look like the following figure:




### *Sound Pressure Level (acpr2)*

1 In the **Model Builder** window, under **Results** click **Sound Pressure Level (acpr2)**.

2 In the **Settings** window for **3D Plot Group**, locate the **Plot Settings** section.

3 Clear the **Plot dataset edges** check box.

### *Selection 1*

1 In the **Model Builder** window, expand the **Sound Pressure Level (acpr2)** node.

2 Right-click **Surface 1** and choose **Selection**.

3 Select Boundaries 3, 5, 6, and 8 only.

### *Line 1*

1 In the **Model Builder** window, right-click **Sound Pressure Level (acpr2)** and choose **Line**.

2 In the **Settings** window for **Line**, locate the **Expression** section.

3 In the **Expression** text field, type `1`.

4 Locate the **Coloring and Style** section. From the **Coloring** list, choose **Uniform**.

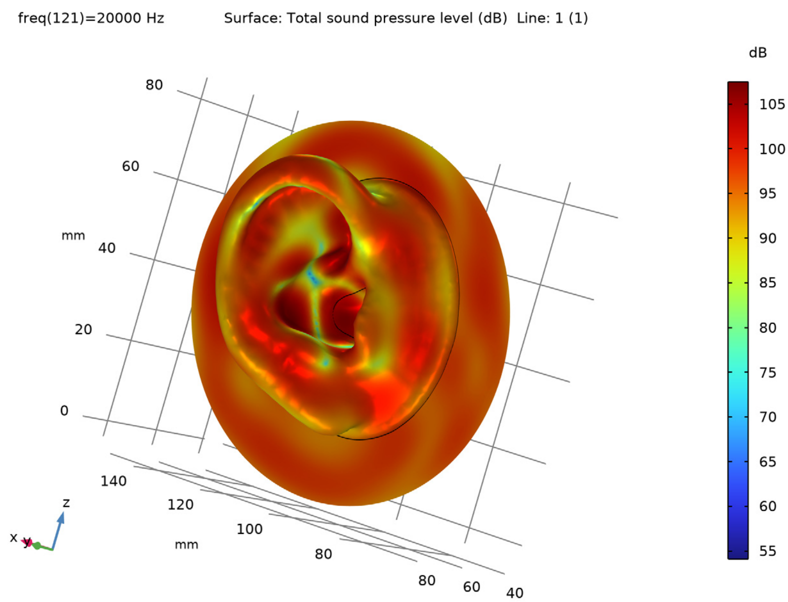
5 From the **Color** list, choose **Black**.

*Selection 1*

1 Right-click **Line 1** and choose **Selection**.

2 Select Edges 6–9, 13, and 14 only.

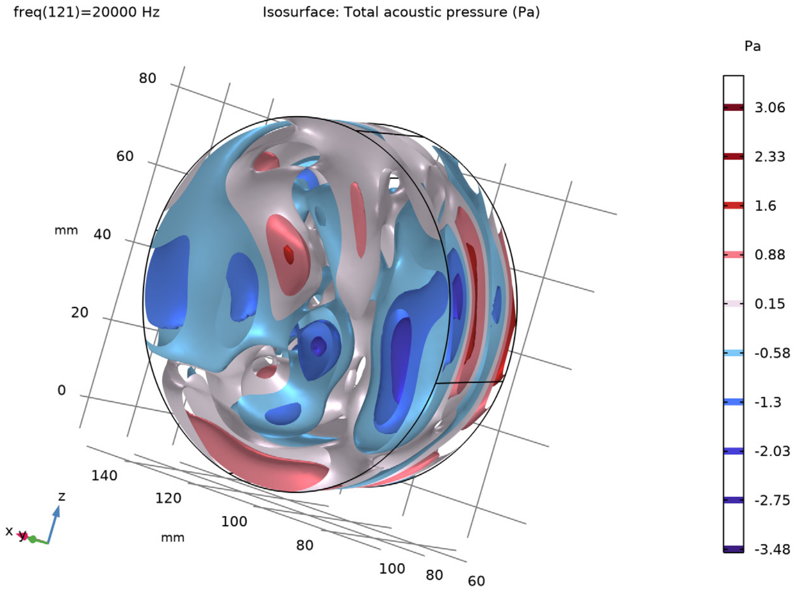
3 In the **Sound Pressure Level (acpr2)** toolbar, click **Plot**.




*Acoustic Pressure, Isosurfaces (acpr2)*

1 In the **Model Builder** window, under **Results** click **Acoustic Pressure, Isosurfaces (acpr2)**.

2 In the **Acoustic Pressure, Isosurfaces (acpr2)** toolbar, click **Plot**.




*Ear Drum Response of Open Ear*

1 In the **Home** toolbar, click **Add Plot Group** and choose **1D Plot Group**.

2 In the **Settings** window for **1D Plot Group**, type `Ear Drum Response of Open Ear` in the **Label** text field.

3 Locate the **Data** section. From the **Dataset** list, choose **Study 2 - Full Ear/Solution 2 (sol2)**.

4 Click to expand the **Title** section. From the **Title type** list, choose **Label**.

5 Locate the **Axis** section. Select the **x-axis log scale** check box.

*Octave Band 1*

1 In the **Ear Drum Response of Open Ear** toolbar, click **More Plots** and choose **Octave Band**.

2 In the **Settings** window for **Octave Band**, locate the **Selection** section.

3 From the **Geometric entity level** list, choose **Boundary**.

4 From the **Selection** list, choose **Ear Drum**.

5 Locate the **Plot** section. From the **Quantity** list, choose **Continuous power spectral density**.

**6** In the **Ear Drum Response of Open Ear** toolbar, click **Plot**.