Trying to make do with 10-band (graphic) EQ

Note: this document is part of an instructional series. If you would like to start with more foundational background information on the nature of sound, check out the previous entries at Headphone Essentials.

Very few headphones come even reasonably close to matching the accurate frequency response for the hearing of a statistically average/normal human being. Your hearing almost certainly differs from the statistical norm in at least small ways. And your listening preferences likely differ from strict accuracy as well. You can hop on the merry-go-round of trying to find a pair of headphones that tolerably matches your hearing and preferences. By all means. Or you can use EQ (equalization) to modify a headphone's frequency response to match your needs. Few audio playback devices, including smartphones and laptops, lack at least a 10-band graphic EQ tool. (Sadly, Apple iOS products are the glaring exception.) Their interfaces vary wildly:

Fig. 1

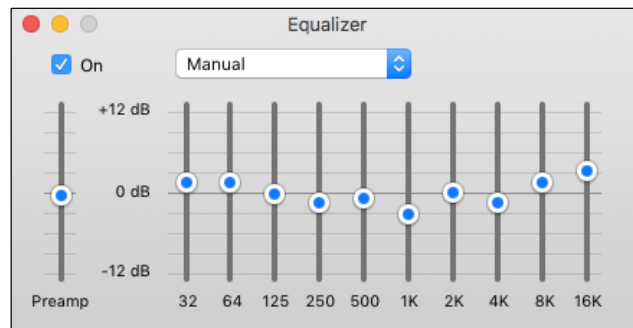The one on my aging MacBook looks like this:

Fig. 2

Bare-bones but serviceable.

1. Getting started

On the left the preamp slider allows you to increase or decrease overall loudness. The main grid area to the right of that is the actual equalizer control panel. Here you fine tune the loudness of individual ranges of frequencies/pitches:
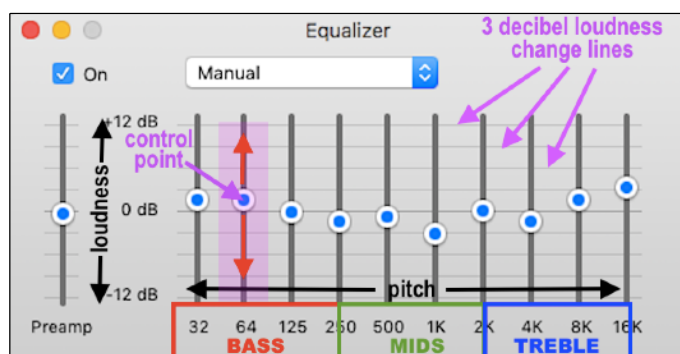

Fig. 3

The blue-in-white circles are the loudness slider control points. These move up and down only. Each slider controls the loudness in one pitch band. The ten sliders range from deepest bass on the left to shrillest treble on the right. The deepest bass slider is labeled 32. 32 changes in sound pressure per second, or hertz, is the approximate pitch of the lowest C note on the piano keyboard, while 250 hertz is close to the fourth, or middle C, 2K equals 2000 hertz, or 2 kilohertz, and is close to the third C after that. 4K is the next and last C on the piano and close to the highest pitch that can be used for making music. But our hearing extends even higher still. You can hear what all these pitches sound like by using the Online Tone Generator:
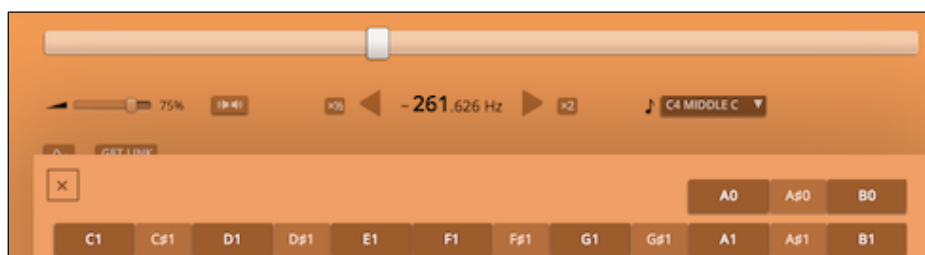

Fig. 4

Notice that raising or lowering any one slider doesn't just affect the single frequency number assigned to it. The loudness change tapers off gradually to it's left and right.

If your goal is to simply add more bass and your headphone happens to have a rare flat-line bass to begin with, you would do so like this:
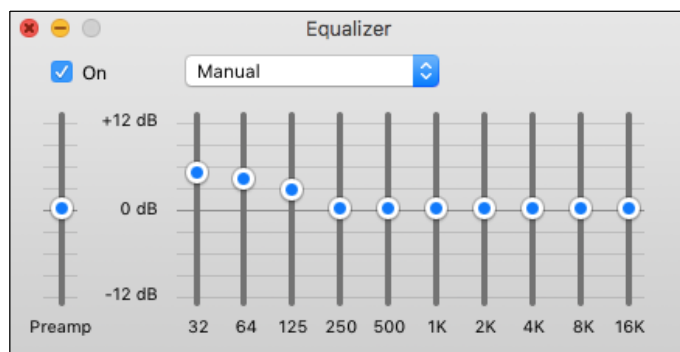

Fig. 5

The important thing is to taper off your bass boost at or before the 250 hertz mark. How much bass this buys you, however, depends on how flat the frequency response of your headphones is in the bass range. Many headphone models have a natural tapering off of the lowest bass frequencies (as we see in Fig. 6). You can get a feel for where your headphone is naturally louder or quieter across the frequency range by moving the Online Tone Generator slider left and right with no EQ active.

2. When things go right

However, the human ear plus brain combo is no match for electronic test equipment at making these determinations. You can find technical measurements for most of the respected headphone models online. But a great site for this is the Headphone Database. Here's a measurement graph for the popular planar magnetic Hifiman HE400i (2020 revision) headphone (see my tutorial for detailed instructions):
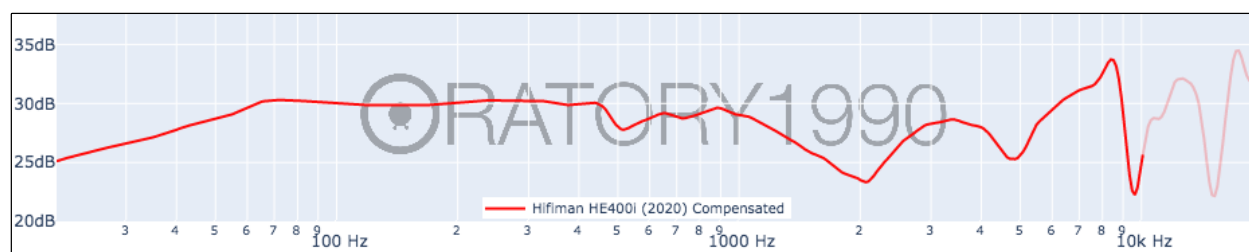

Fig. 6

This is the compensated-only version of the measurements, and the accurate/neutral Oratory1990 Optimum HiFi option has been used to do the compensating. The red line looks more like the overhead view of a drunken snail's path than a frequency response. A straight red line from left to right would indicate a perfectly neutral frequency response. But first we need to get oriented:
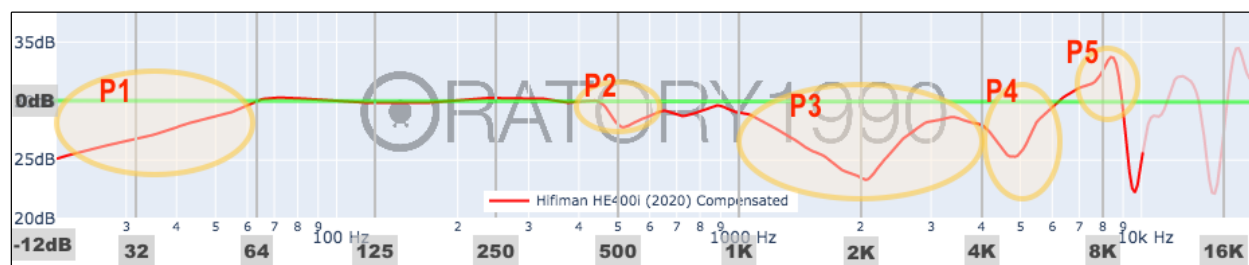

Fig. 7

Here I've overlaid the grey frequency and loudness numbers from the iTunes EQ interface onto the HE400i graph. I also set the graph's neutrality/accuracy baseline, marked as 0 dB, at the measured 30 dB level using a green line. Any departure up or down from that line is a departure from a theoretically accurate playback of the recording. A one decibel change is typically just barely audible. A three decibel change is audible but not glaring. A six decibel change is quite obvious, representing an actual doubling or halving of sound pressure. I circled the five main problem areas, P1 through P5, in pale orange. These are places where the red line strays noticeably from the green line.

P1 points to a drop-off in the sub-bass. Very little music content extends that low. Even so it shouldn't hurt to boost the 32 dB slider by 3 decibels to address this:
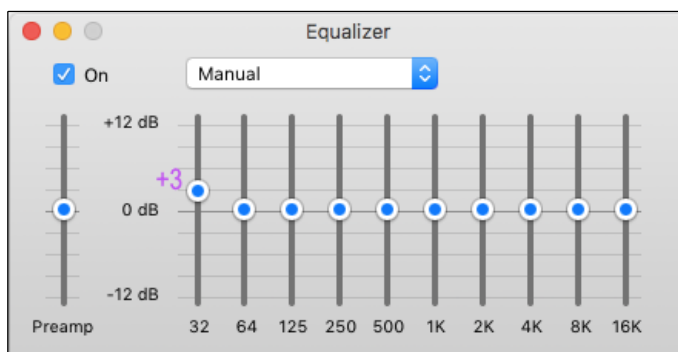
Fig. 8

If instead I want to increase the 400i's bass beyond the flat-line neutral level, I would need to taper the boost off at or before the 250 hertz start of the mid-range, as in Fig. 5. However, the bass is one area in which the speakers inside a headphone can't handle an unlimited amount of increase. Bass is where the most potential for distortion typically occurs.

Going back to Fig. 7, P2 at 500 Hz is easily corrected with a 2 decibel boost of the 500 Hz slider. P3 is a doozy and needs a 7 decibel increase of the 2K slider, plus a 2 decibel increase of the 4K slider. Finally, the only slider close to the P4 dip is again the 4K one. So we would experiment with bringing that up to a total of 5 decibels increase. Beyond P4 there are multiple peaks and valleys, but this high up in the frequency range there is unlikely to be much correspondence between how your ears interact with the headphone and how the measurement rig did. So all we can do is experiment with the 8K and 16K sliders to see if any change results in an overall improvement when listening to a wide variety of music.

Here are all the changes. Notice how the ups and downs form an inverse mirroring of the red line in Fig. 6:
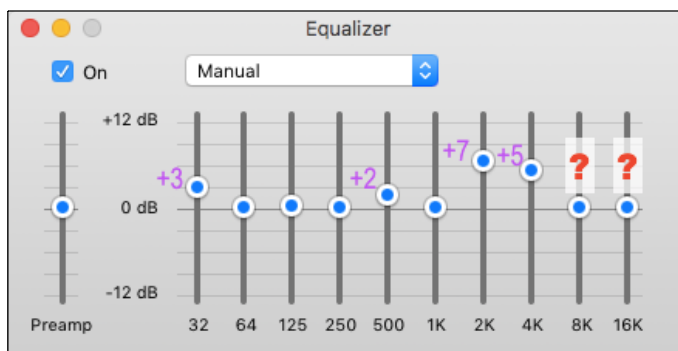

Fig. 9

3. When things go wrong
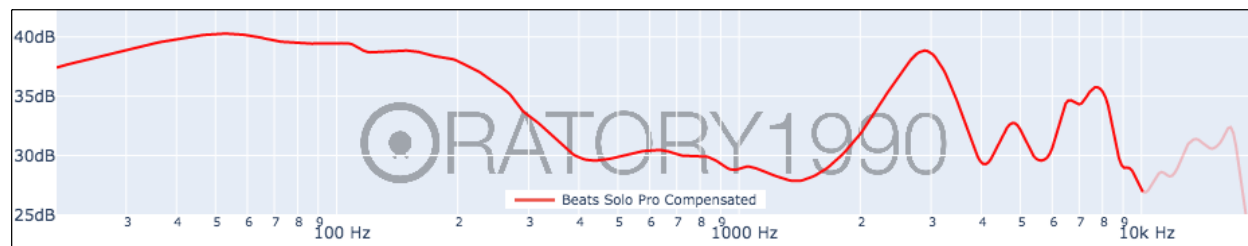
Now, let's look at a very different headphone:

Fig. 10

The Beats Pro is what's called a bass cannon, as we can see from Fig. 10. However, moving on to Fig. 11, I'm leaving the whole area to the left of the 125 hertz line alone. Presumably, if you own a Beats Pro you want something like that level of bass boost. If it's too much, great — just lower the 32 dB and 64 dB sliders in your EQ app to taste.
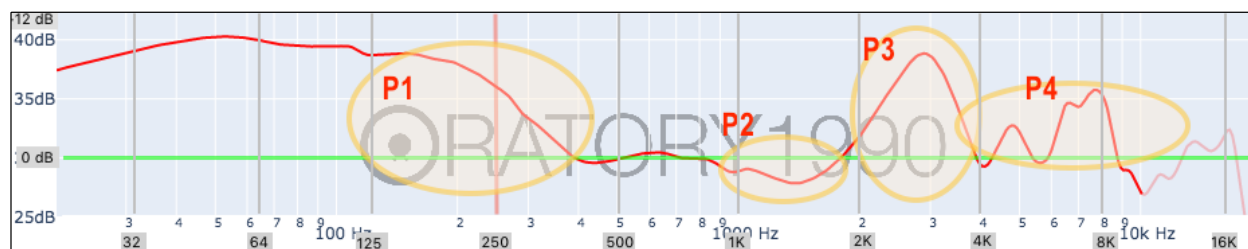

Fig. 11

However, P1 is circled because the Pro's bass boost extends past the critical bass-to-mids transition line at 250 Hz. The Pro's boost extends into the baritone portion of the mid-range, not reaching the green reference line until 400 hertz. Just reducing the 250 hertz slider is not enough. That would create too steep a transition from bass to mids. The 125 hertz slider needs to come down a bit as well:
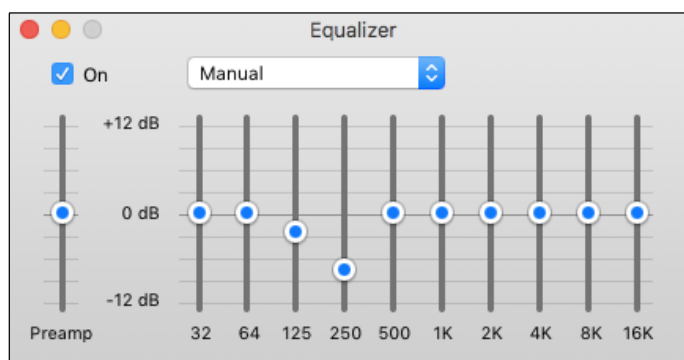

Fig. 12

But P2, P3 and P4 are another kind of problem all together. We really need a 1.5K slider to address P2, but none exists. We need a 3K slider to address P3, but none exists. The 8K slider is in a good position to correct the bigger peak in P4, but doing so creates a major valley at 5.5 kilohertz. You can play with the 1K, 2K, 4K and 8K sliders to see if you can achieve an overall compromise improvement. But any changes will typically introduce as many new problems as they provide solutions. That said, the particular unit (or units) of the Beats Solo Pro that Oratory1990 measured is not the one you purchased, and unit variation is definitely a factor. Plus, again, your ears are not the statistical average ears used to make the measurements. So it's always possible you can find a set of adjustments that result in a net improvement.

The sliders of a 10-band graphics equalizer are one octave apart, so there are 11 notes between each pair of sliders that are not being precisely covered. The Beats Solo Pro is a case in point for just how inadequate the 10-band graphics equalizer can be. Yet, all too often, that's all that's available on a given system.

Further graph resources

Another problem is that the odds that you'll find the headphone model that you own on the Headphone Database are not great. There are a variety of other sites with usable measurements. You can find discussion on them in my previous unit in the Headphone Essentials series: The skinny on headphone frequency response graphs. In summary, at this time I use the two Oratory1990 collections as my go-to source. If the headphone model I'm

looking for isn't available on the Headphone Database, I check his EQs collection. If it's not there either, I check crinacle.com. I also follow The Headphone Show on YouTube and download the Resolve GRAS graphs that typically accompany each of his reviews. If I still haven't found a graph for the model headphone I'm looking for, I go to the AutoEQ site to see if it's listed there on one of the non-GRAS measurement sites, such as rtings.com or InnerFidelity. If so, I go to the site referenced to get the frequency response graph provided there.

> **AutoEQ** would seem like the obvious go-to location to by-pass all the above. Sadly, for graphic EQs like the 10-band ones we've been dealing with, both AutoEQ and Oracle1990 have the misunderstanding that graphic EQs can be emulated with a simple 1.41 Q parametric EQ equivalent (don't worry if that doesn't mean anything to you). the upshot is that their 10-band EQ pre-sets are often significantly inaccurate.

Working with a raw data graph

These other sites do not provide the convenient neutral-compensated graphs we've been using. Instead, they provide raw data graphs. The raw data graph option is also available on Oratory Grapher, we've simply ignored it. For example, the Hifiman HE400i/2020 graph we used above looks like this by default:
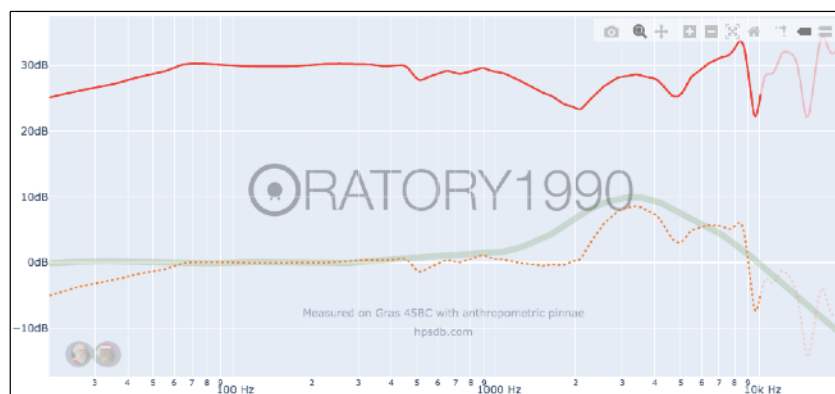

Fig. 13

The faint dotted orange line is the raw data curve and the pale green line is the neutrality target curve for reference. The solid red line we've been working with is simply the divergence of the raw data (dotted orange) from the green target at each frequency. If you could pull the green line straight like a piece of string and have the dotted orange line tag along with it, you'd get the solid red line. Consequently, the solid red line is just a convenience. Once you get the idea you can use a raw data graph just as well.

For example, let's say you want to EQ the venerable Philips SHP9500 using the Crinacle graph:
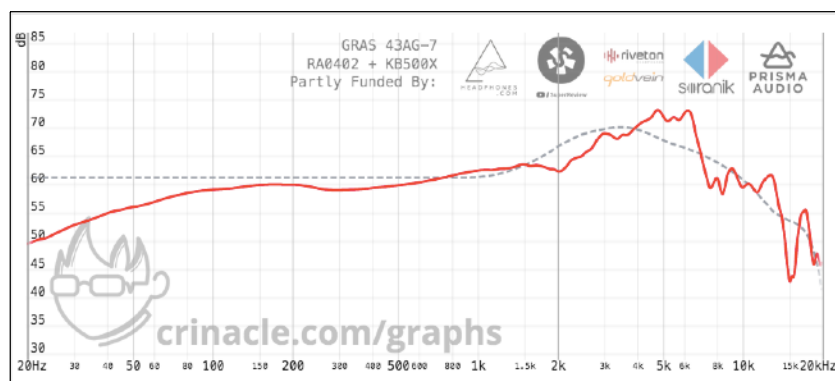

Fig. 14

By all means try working with the non-standard reference curve Crinacle provides as the grey dotted line shown in Fig. 14. Perhaps it will provide a neutral sound for your ears, as well. If not, you need to replace it with the technically correct curve you see as the green line in Fig. 13 or some variant of it that you've found fits your own hearing best.

For Fig. 15 I've used the simple drawing/painting app that came with my MacBook (on Windows the equivalent is simply called Paint) to sketch in the Oratory neutrality curve:
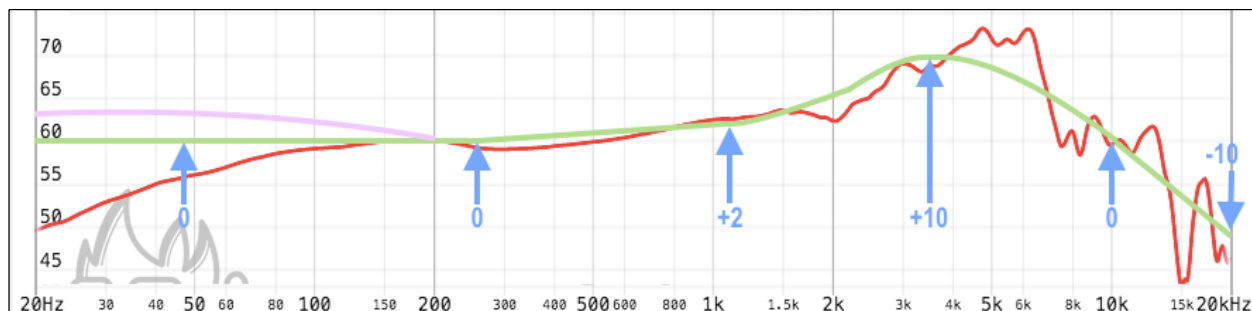

Fig. 15

Alternatively, you could print the Crinacle graph then pencil in (or trace) the reference curve by hand. No great accuracy is required. The key requirements are that you have:

1. A straight line running from the far left (20 hertz) out to 250 hertz), followed by
2. A slightly up-slanting line from 250 to just past the 1k point, where it has risen to 2 decibels higher than the first line. Since I've arbitrarily put the baseline at 60 on the left hand decibel scale, the second line rises to 62.
3. Now you want a gentle curve continuing from just past the 1k point that peaks at 10 decibels (in this case 70 on the left hand scale), then falls back to 0 again at the 10k point.
4. Finally, your new green line drops diagonally down to -10 (50 on the left hand scale) at the right edge of the graph.

Note that I've also added a purple line on the left as an example of what would be a common departure from strict neutral of a moderately elevated bass — that importantly tapers down to 0 at or before the 250 hertz bass-to-mids transition point.
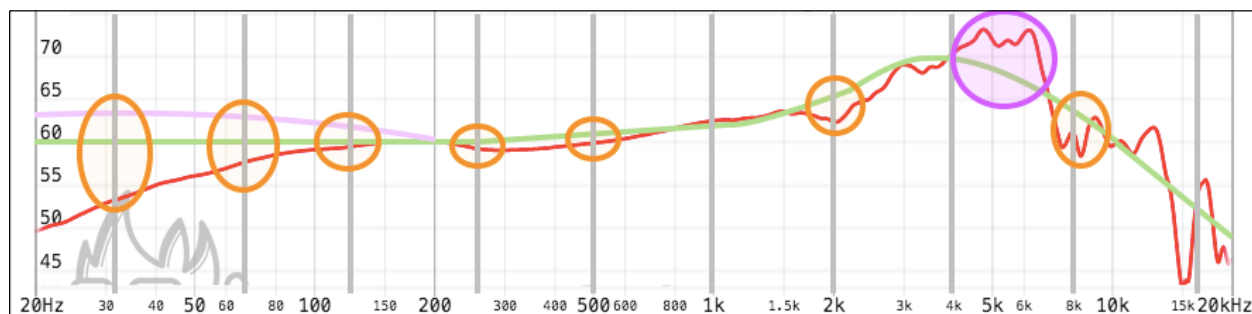

Fig. 16

The next step is to sketch in the 10-band controls which I've done using grey vertical lines at 32 hertz, 63 hertz, 125 hertz, etc. Now you can circle the changes you need to apply to bring the red line up or down to match the green line. So at 32 hertz eyeballing the graph shows we need to add about +7 (decibels) to get to the green line, or +10 to get to the purple bass boost line. Similarly, we would bring the 63 hertz slider up by +2½ for neutral and +5½ for a bass boost. Continuing, we end up with Fig. 17 as the correction for a neutral bass scenario:
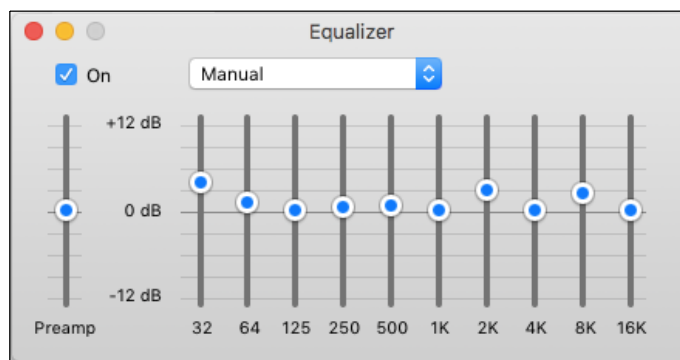
Fig. 17

But note that the problem spot I've circled in purple falls between the 4K and 8K controls, once again leaving us with no good correction to apply. If this problem is the one you most want to address, the best you can do is drop the 4K control the minimum amount that's acceptable to your ears then live with the inaccuracy that results in centred around the 3K region (and for some genres that might be a benefit not a drawback).

✤ ✧ ✤ ✧ ✤ ✧ ✤

And that concludes this episode of the Headphone Essentials series. The next episode tackles the questions of how much power you need for your headphone and which amplifiers can supply it?