Setting up a Turntable -Theory (written in 1999)

Turntables fall into two basic categories, ie. those suspended by springs and non suspended turntables with minimum isolation provided by elastic feet.
Suspended turntables usually resonate in the range of 2-6 Hz, which is below the resonance of the tonearm / cartridge assembly. The suspension system filters vibrations above the resonance of the system but is very sensitive in the resonance range of the system and also allows through vibration below the range down to zero Hz.
To avoid heavy movement of sub-chassis, platter and tonearm, some sort of damping is used in the spring suspension. This restrains movement of sub-chassis and improves sound quality but it also lowers filtration of the system, which accepts more vibration at frequencies above the resonance.
Systems with minimum elasticity (with rubber feet or other exotic material) also resonate but at a higher level of between 10-50 Hz. They are usually heavily damped to prevent movement between motor and platter but are sensitive to vibration and acoustic feedback.
The system will be less sensitive to vibration if it has lower resonance and less damping but will, accordingly, allow more movement to take place between motor and platter and the sensitivity of the tonearm to this movement will cause unstable sound.
The use of a highly damped system will give a stable drive, but the additional vibrations will bring the sound forward and cause loss of definition in lower registers.
Any turntable will be less sensitive to vibration if it has a high mass. A low mass chassis is only useful in that it creates higher resonance with less stored energy, causing smaller movements. Such systems fail to reproduce low frequency energy, filtering it out and creating an artificially cleaner sound which can help a simple system to apparently perform "better".

Supports
The best turntable support is a rigid stand which does not have low frequency resonance to interfere with the resonance of the turntable suspension. A stand is sensitive to vertical floor vibration but, being raised, will also be sensitive to horizontal vibration, which will interfere still further with the horizontal resonance of the chassis and ultimately affect drive and tonearm performance.
If the turntable is on a rigid wall support it will be insensitive to vertical vibration but more susceptible to horizontal ones.

In reality there is always a mix of both types of vibration along with torsional ones.
Stabi Reference suspended turntable for example, will effectively filter out frequencies above 3-4 Hz. With a mass of 40 kg, and its own resonance of 2.2 Hz, if placed on a wobbly stand it is likely to resonate in the range of the turntable resonance. A very rigid stand will resonate above the turntable resonance thus effectively filtering out higher resonances.

The turntables own suspension will, additionally, filter resonances in a lower range and the damping will prevent chassis movement. If a suspended turntable, without damping, is placed on a stand we have to ensure that the resonance of the stand is well above the turntable's own resonance. In this case the turntable will filter out the stands horizontal movements. If the resonance of the stand is below the turntable suspension resonance, then the whole turntable will move, creating problems in drive. The tonearm will also move separately, creating wow. The resonance of suspension, tonearm and support might be quite close and will interfere with each other. There can even be different resonance in the stand in different directions, ie. back and forth can be different from side to side.

Turntables with minimum suspension do not have this problem but will be more sensitive to all vibration of the stand. Turntable and stand resonance will usually be in the range of tonearm resonance, so once again, a very rigid stand with high resonances, self damped in the stand is better.

Additional supporting platforms can work very well with some turntables, while creating problems with others. A platform with air suspension and low mass will audibly resonate and cause a confused sound. To decrease the resonance, mass must be added. The best platforms combine high mass and low resonance in the range of 2-3 Hz. It is useful if the mass used is a rigid supporting plate, which dampens vibrations in the turntable structure itself but, once again, care must be taken to avoid resonance of the stand and turntable itself.

Levelling
The turntable should be level on the stand by use of spikes, feet, screws or adjustable legs on the turntable. Adding mass, adding the platter for example, will affect the suspension and alter the horizontal level. If the turntable frame is horizontal and the platter parallel to this then all is well. If the turntable has minimal suspension then this will not be a problem.

Adjustments
Manufacturers instruction manuals should be used when adjusting turntables and tonearms.

Tonearm Mounting
If mounting a tonearm on a turntable without a precut arm board, ensure that fit is correct by measuring the distance from the pivot to tonearm , being careful to leave space for counterweight and checking that height allows for lid closure. In suspended turntables care must be taken to fix cables in such a way that it does not interfere with the suspension. Turntables with damping and a heavy sub-chassis are less sensitive to this problem.

Cartridge Mounting
It is necessary to be very careful during this process, to use good screwdrivers or Allen keys and a good pair of tweezers. Once the cartridge is fixed in the head shell ensure that the cartridge is parallel to the sides of the head shell and that the distance from the tonearm horizontal bearing to the diamond tip is the effective length of the tonearm. This depends on the distance from tonearm pivot to spindle. If it is longer then the data provided in tonearm specifications then the effective distance from pivot to diamond tip is longer and overhang is shorter.
What is stated in the manual is only a starting point. In the case of our tonearms it is at the end of the head shell, so fixing the cartridge is simply a matter of lining up the needle with the end of the head shell.
When cartridge pins are fixed, tracking force should be set to the upper recommended force.

Tonearm adjustment
Bias or anti-skating force should be adjusted by use of the instruction manual and not by use of a blank test record. In this case the tip of the needle merely slides across a flat record surface and this has no relation to a needle tracking a heavily modulated groove.

Bias force is necessary to counteract the force pulling the tonearm in the pivot direction. Due to tonearm geometry (with the exception of parallel tracking tonearms), this force pulls towards the center of the record. This force is affected by the modulation of the groove and where the groove is, ie. how far from the center of the record. In order to equal the pressure exerted on both sides of the needle, bias force pulls the tonearm towards the outer edge of the record. The signal from test records can be seen on an oscilloscope, especially in heavily modulated tracks where the bias lowers or eliminates distortion. Signals can be heard as added harmonics to pure test sound. If this is heard on one channel only, it is an indication that bias is too low. If it is on both channels then it is probably too low tracking force or cartridge is on its max. tracking capability.

Cartridge Adjustment
For minimum tracking distortion geometry, it is necessary to use a protractor. For Kuzma Stogi tonearms see details in our instruction manual. There are various theories about optimum tracking geometry as to which gives the lowest distortion over the entire record. Most generally accepted are zero distortion in 66 and 121 mm.

Fine Cartridge Adjustment
Two parameters are of particular importance are VTA (vertical tracking angle) and azimuth.

VTA is changed by tonearm height and tracking force.
Azimuth controls the cartridge angle which should be parallel to the record from a front view.

The better the system, the more important these two parameters become, especially as better cartridges have thinner diamond profiles which more closely resemble the profiles of the triangular cutters.

Azimuth can be set by measurement using a test record but VTA can only be adjusted by listening. While VTA can differ from record to record, azimuth is basically the same for all. Unfortunately different test records give different results so, after measurement of azimuth using a test record, it is worthwhile making further fine adjustments, particularly if the tonearm allows for fine, repeatable adjustments as in Stogi Reference and Stogi S tonearms.

In most tonearms changing the VTA also changes azimuth but many tonearms ignore the importance of azimuth adjustments. The effect on sound, however, can be dramatic. Perfect adjustment of VTA and azimuth can make an apparently distorted and worn out record sound like a master tape.
In general , fine tuning a turntable, tonearm and cartridge to achieve the very best sound, is a long process. Precise VTA is difficult to achieve and, in reality, nearly impossible to change for each record. It is worth, however, looking at our Stabi XL turntable which allows adjustment of VTA during play, without affecting rigidity and without losing azimuth, and also allows simple return to any previous position, over a range of 12 mm.

Practical Suggestions for VTA and Azimuth Adjustment
As a basic rule, if the VTA is too high, the sound will be harsh, too open, thin, metallic and analytical at upper frequencies. Some people find this convincing.

If the VTA is too low then the sound tends to be muffled with a big bass and a more rounded sound.

When VTA is correct the sound falls into focus. In a good system correct VTA is easy to establish but if there are basic flaws in the system it can be difficult and frustrating.

I suggest that you listen to midrange sounds, preferably with a natural vocal recording. As VTA is different for each record, a compromise must be reached. Beware of falling into the trap of accepting a too HIFI sound as opposed to a less bright , less spectacular, but more correct sound.

VTA
To start adjusting VTA have the tonearm tube parallel to the record and try a few settings of 3-4 mm below and above this reference point. Then mark the best sound and do fine VTA adjustments around this new marked level in the range of 0.5 mm (1/50 inch). The optimum height is often found when the base of the tonearm is lower than when the tube is parallel to the record surface. (If the tonearm has a conical tube, this parallel line is the imaginary one running through the middle of the tube.)

It is also advisable to check absolute phase by reversing all connectors to the cartridge where such a change has the biggest effect (white with blue and red with green). Listen and check weather the soundstage is deep and focused and presentation of singers convincing.

Azimuth
Correct azimuth will have a similar effect as correct VTA except it will be the same for almost all records. Incorrect azimuth causes lack of focus, distortion of loud passages and muffled details. Again, the better the system, the bigger the difference.

In order to adjust azimuth use of a mono recording and connecting leads to the cartridge in such way that we can hear minimum output from one speaker, is not good enough. This does not give correct azimuth.

It is possible to adjust azimuth by ear but extremely difficult. The correct and simple way is to use a test record and an oscilloscope. The oscilloscope should be dual trace (though this is not essential) so that we can easily observe both channels on a test record at the same time. The test record should have test signals of 300 Hz or 1 KHz or 3 KHz recorded separately for left and for right channels. (Separation tracks). With the oscilloscope we can see test signals and the aim is to adjust cartridge azimuth so that crosstalk signals are equal for both channels. That is, to make separation from left channel to right the same as from right channel to the left .

When we play the left channel we can see the sine wave of the full size signal while on the right channel we will see the very small signal which is the crosstalk from the left channel. By adjusting the oscilloscope so that both signals have the same reference zero and, with appropriate amplification of signals, we can observe the left channel signal which is so big that it is off the screen and the small crosstalk signal. Keeping in mind the size of the crosstalk signal, we then play the right channel from the test record and observe the crosstalk signal of the right channel. We will see that they are not the same. Changing azimuth will change both. One will be bigger, the other will be smaller. When the azimuth is correct they will be the same. Sometimes the differences are very small. Due to tonearm resonance the whole signal will jump up and down on the screen . Use of a filter below 200 Hz makes reading of the signals much easier.

After finding the correct azimuth you should again listen to ensure VTA is correct and re-check absolute phase. Any change of VTA will affect azimuth (though not on the tower of our Stabi XL turntable) so this will need re-adjustment. By taking these small steps we will eventually obtain almost perfect cartridge set-up, providing of course that we do not change tracking force. Finding the sweet spot with tracking force and making appropriate adjustment necessitates repetition of the whole process. Now try to imagine the task of reviewing cartridges or even tonearms for magazines!
Have fun and remember, if changes in sound are very small then they are not important.

Franc Kuzma , 1999.

PS: Addition in 2016:
These days you can set up azimuth by various programs or products like Dr. Feickert Adjust Plus, Fosgate,..... and VTA you can set up by digital microscopes.

See for more detail information about how to set up cartridge and tonearms in **KAA 2016 Analog Academy** book which is available on our web site in pdf.