

TuneLab Pro

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What is TuneLab Pro ?

TuneLab is software that helps you to tune pianos. This software comes in various forms - TuneLab Pro (for Windows laptops), TuneLab Pocket (for the Pocket PC), and TuneLab for Smartphones (for Windows Mobile Smartphones). Although these platforms are quite different, most of the features of TuneLab are implemented similarly in all versions. This manual describes TuneLab Pro. There are separate manuals to describe TuneLab Pocket and TuneLab for Smartphones.

Visual Tuning

TuneLab is one of the class of devices or software programs called “Visual Tuning Aids” or “Electronic Tuning Devices”. These are devices or programs that provide a piano tuner with real-time guidance during tuning. The sound of a note as it is played is picked up by a microphone and analyzed. The results of the analysis are displayed in a visual pattern. In the case of TuneLab, there are two main visual patterns that are displayed - the **phase display** and the **spectrum display**. Both of these displays indicate if the pitch of a note should be raised or lowered, but each display has its own unique advantages. Having both displays visible simultaneously gives the piano tuner the best of both worlds.

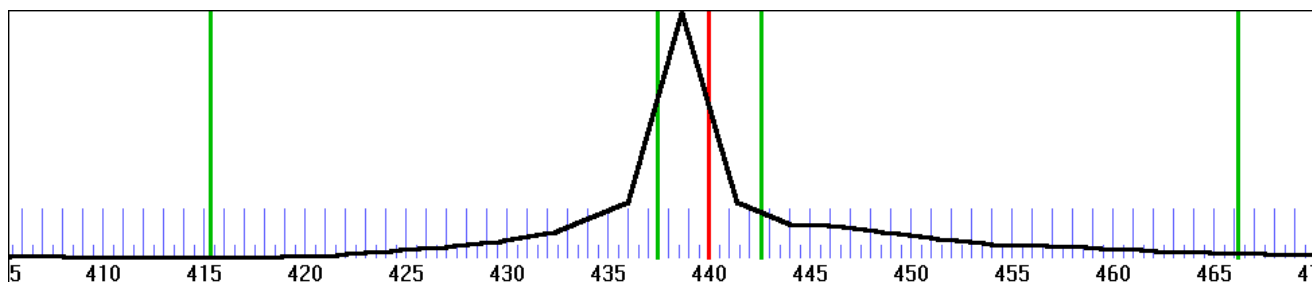
Phase Display



The phase display is the horizontal band shown above. This display is used for fine tuning. The black squares move to the left if the note is flat and to the right if the note is sharp. The closer you get to the correct tuning, the slower the black squares will move. The goal is to make the black squares come as much to a stop as possible. If the piano string has any false beats then the black squares may appear to move in an irregular fashion, sometimes moving back and forth. When there is no note playing, or when the note being played is far from the correct pitch, the black squares will disappear or move randomly.

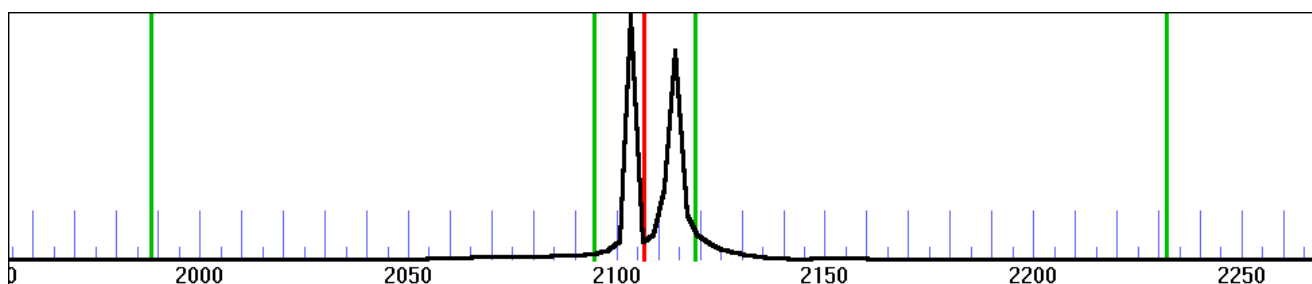
This display is called a phase display because it displays the phase of the sound from the microphone as compared to the phase of an internally generated reference pitch. The movement of the squares can be compared to listening to beats between a tuning fork and a note on the piano. For the bass and midrange, when a square makes one complete trip around the display, that corresponds to one complete beat that you would hear when comparing two tones. For higher notes the display is artificially slowed down in order to keep the speed of the display in a reasonable range.

Spectrum Display



The spectrum display is the graph shown above zoomed-in to ± 130 cents around the desired pitch. Using the Edit Options menu, you can choose to make the traces thicker (as shown) for easier visibility, at the cost of a slight loss of resolution. This display shows how the sound energy is distributed across the frequency spectrum. If TuneLab is listening to a pure tone, then the spectrum graph will show a single peak. The example seen here was made from a A-440 tuning fork that was actually a little flat. The red line in the center of the display marks the correct pitch. The green lines nearest the center mark the points that are 10 cents above and below the correct pitch. The green lines far from the center mark the points that are 100 cents above and below the correct pitch, i.e. the previous note and the next note. The object in tuning with the spectrum display is to tune the note until the peak of the graph is centered on the red line.

The spectrum display has several advantages over the phase display. One is that it shows where the pitch of the piano is, even when that pitch is far from the correct pitch. The other advantage is that the spectrum display can show several peaks at once. This is what you would get when playing a poorly tuned unison:



















Here the piano note C7 is being played with one string tuned nine cents higher than the other two strings. By looking at individual peaks it is possible to tune notes in the high treble without mutes! You simply tune one of the strings and watch which peak moves. You can move that peak to the red line and then that string will be at the correct pitch. However, tuning this way is not as accurate as tuning by sounding one string at a time, because the multiple peaks tend to become blurred as they merge into one another.

One advantage of the phase display is that it generally provides more resolution than the spectrum display, except in the highest octave where the resolutions are about the same. For this reason the spectrum display is used for rough tuning and the phase display is used for fine tuning. False beats can confuse the phase display, though. So the spectrum display is preferred even for fine tuning in the high treble. In any case, both displays are available; so you can use whichever display seems to be giving the clearest indication.

Toolbar

TuneLab Pro uses a toolbar for many functions. Here is the toolbar from TuneLab Pro:



-  **New Tuning File** - prepares for creation of a new tuning, and may start auto measure sequence
-  **Open Tuning File** - selects and load an existing tuning file
-  **Save Tuning File** - saves the current tuning in a file so it can recalled later
-  **Sound On/Off** - toggles the sound generation mode on and off
-  **Note Lower** - switches to the next lowest note. (← on the keyboard also works.)
-  **Note Higher** - switches to the next higher note. (→ on the keyboard also works.)
-  **Zero Offset** - clears the offset to zero. (Z on the keyboard also works.)
-  **Lock Mode** - begins locking onto the note by automatically adjusting the offset (‘.’ also works.)
-  **Zoom Out Spectrum Display** - zooms out to show a wider range (“-” also works.)
-  **Zoom In Spectrum Display** - zooms in to show a narrower range (“+” or “=” also works.)
-  **Auto Note Switch, Both Direction** - enables auto note switching in both directions
-  **Auto Note Switch, One Direction** - enables auto note switching in just one direction
-  **Measure Inharmonicity** - measures inharmonicity or current pitch in over-pull (pitch raise) mode (**M**)
-  **Over-pull** - enables/disables over-pull (pitch raise) mode (**F2** also works.)
-  **Historical Temperaments** - selects optional non-equal temperaments
-  **Tuning Curve** - displays the tuning curve for adjustment or review (**T** also works.)

All these toolbar buttons have associated tooltips. To see a tooltip, merely move the mouse cursor so that it rests on one of these buttons. After a short pause a box will appear with a reminder about what that button does, as shown to the right. If there is a keyboard key that performs the same function, the tooltip will tell you about it.



Current Settings Display

In the middle of the main TuneLab display screen in large letters there is a display of the currently selected note. Above the phase display is a display of current settings. Usually most of these fields are blank; but here is an example with all the fields active:

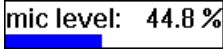
MyKawai.tun	Over-pull = 12.00 ¢
Coleman 11	Custom Stretch = 4.70 ¢
Over-pull by 25 %	Template Stretch = 1.68 ¢
Using Fundamental	Temperament Offset = -2.08 ¢
Frequency = 748.511 Hz	Basic Offset = 3.53 ¢
Current Settings:	
Auto up	

Here is a description of each of these fields, reading down the left column and then the right column:

1. **Tuning File Name** - the name of the tuning file currently in use
2. **Temperament Name** - the name of the temperament file (if one is selected)
3. **Over-pull Percentage** - the current over-pull percentage (if over-pull mode is selected)
4. **Tuning Partial** - which partial (or fundamental) is used for tuning the current note
5. **Frequency** - the calculated frequency, taking into account all offsets
6. **Over-pull** - the offset due to over-pull mode (or the temporary offset if over-pull is not selected)
7. **Custom Stretch** - the offset (if any) manually programmed for the current note
8. **Template Stretch** - the offset calculated from the tuning curve
9. **Temperament Offset** - the offset from the optional historical temperament in effect
10. **Basic Offset** - the offset (if any) applied to all notes uniformly
11. **Note Switching** - “Auto up” in this example, tells which form of hands-free note switching is in effect

Microphone Level Indicator

mic level: 44.8 %

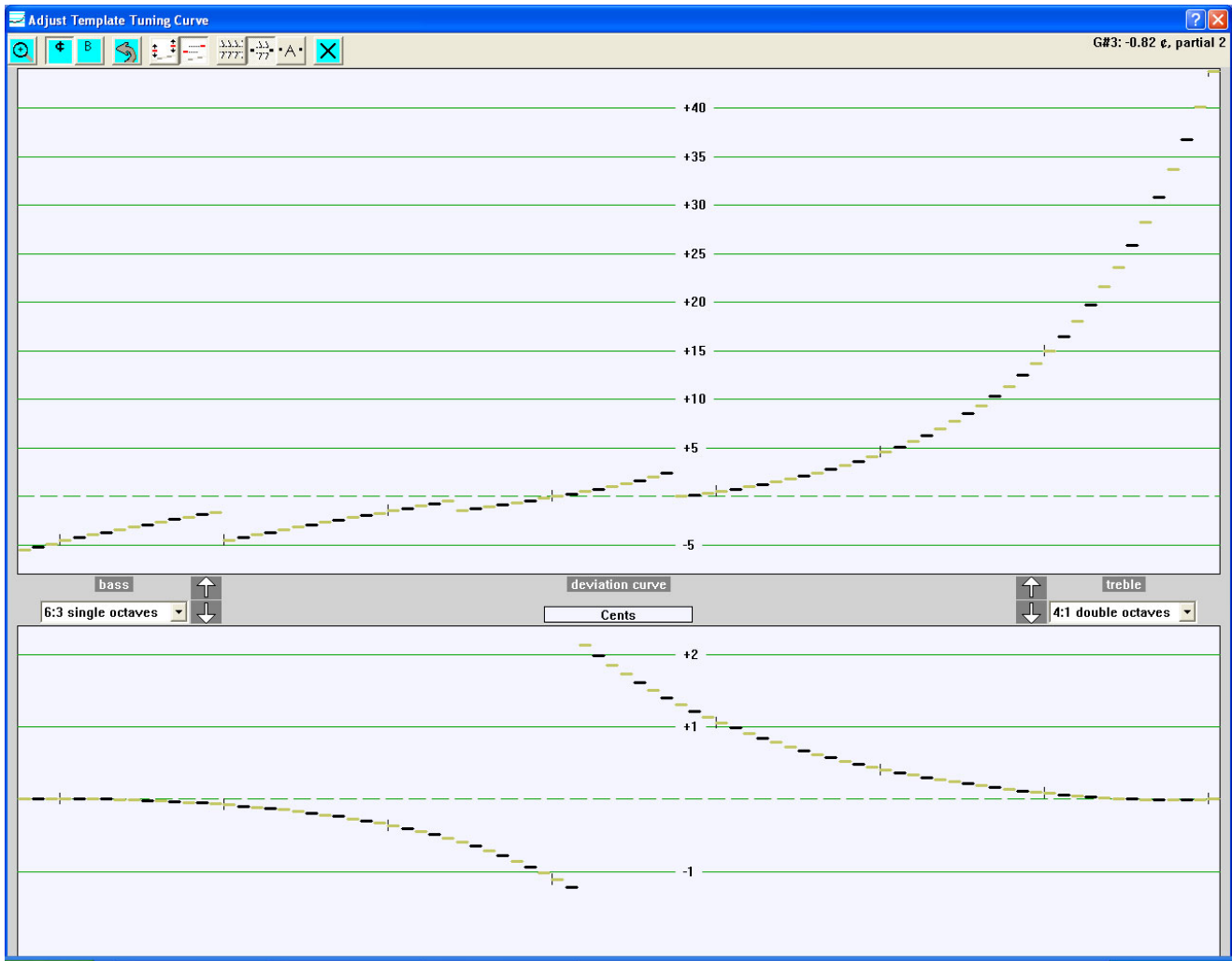


To help verify that your microphone is working properly, TuneLab provides a display of the microphone level in the upper right corner of the main screen. When all is quiet, the level should be below 1%. Normal talking into the microphone should produce a level of at least 50%. If the reported level is nowhere near these levels, then check your microphone and check the multimedia settings in your computer’s Control Panel to see if some system volume control is improperly adjusted.

Tuning Curve Adjustment

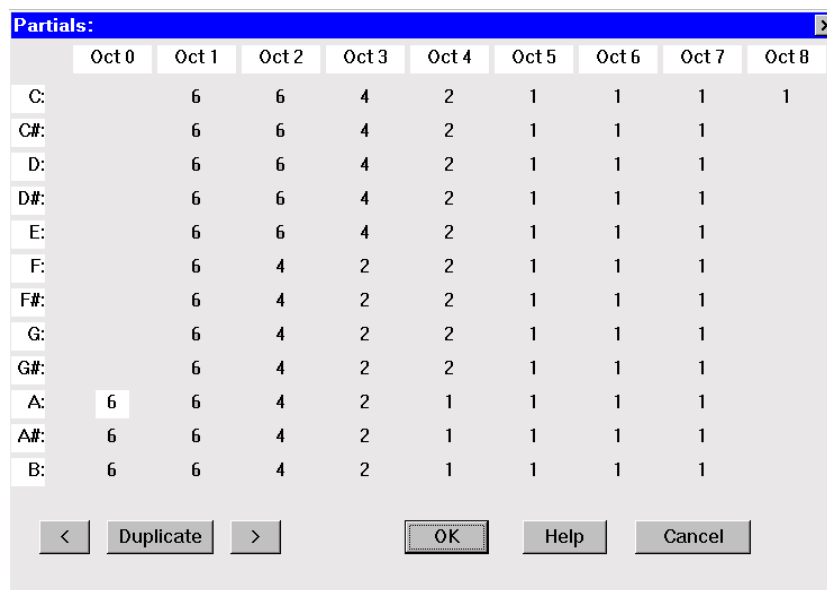
The following image shows the tuning curve adjuster. The tuning curve adjuster contains two different graphs. The upper graph is called the **tuning curve**. For each note from A0 to C8 it shows the calculated stretch in cents. It is this calculated stretch that appears in the current settings display under the name “**Template**”. The arrows below the tuning curve are for adjusting different aspects of the curve. There are three adjustment modes: fully automatic, semi-automatic, and fully manual. Normally we recommend the fully automatic mode. In fully automatic mode, the four inner arrows will all be replaced with the word '**Auto**', and clicking on any one of them will make the fully automatic adjustment. There are three buttons at the top of the display that select among the three adjustment modes. The display shown here includes just four adjusting arrows because the **Auto-A0-C8** (semi-automatic) option has been selected. The lower graph is called the **deviation curve**. It displays information about the two intervals that are selected in the selection boxes just above the graph. As shown we have selected 6:3 octaves for the bass and 4:1 double octaves for the treble. Other intervals may be selected, depending on the kind of tuning you want to achieve. The deviation curve is divided into a left half and a right half. The left half is based on the interval selected for the bass (6:3 octaves in this case) and the right

half is based on the interval selected for the treble (4:1 double octaves in this case). The deviation curve shows how these intervals work out in the tuning. Where the deviation curve shows zero, the selected interval is beatless. Where the deviation curve shows a positive number of cents, the selected interval is wider than beatless by that many cents. Where the deviation curve shows a negative number of cents, the selected interval is narrower than beatless by that many cents. When you use the adjuster arrows to adjust the tuning curve, you are directly affecting the tuning curve. As a consequence of your adjustment of the tuning curve, the deviation curve will also change. Therefore, even though you are directly adjusting the tuning curve, you may assume that you are adjusting the deviation curve as well. Generally, you make your adjustments to achieve a certain appearance in the deviation curve. The procedure for making these adjustments is described in detail in Chapter 2.



Partials

Each note is tuned according to its fundamental pitch or the pitch of one of its partials. The current settings box shows which partial is being used. The selection of partials comes from a table of partials. This table may be modified from the screen shown to the right. The table shows the partial number for each note from A0 to B6. (C7 through C8 are assumed to be using the fundamental.) Using the < and > buttons you can lower or raise the



	Oct 0	Oct 1	Oct 2	Oct 3	Oct 4	Oct 5	Oct 6	Oct 7	Oct 8
C:		6	6	4	2	1	1	1	1
C#:		6	6	4	2	1	1	1	
D:		6	6	4	2	1	1	1	
D#:		6	6	4	2	1	1	1	
E:		6	6	4	2	1	1	1	
F:		6	4	2	2	1	1	1	
F#:		6	4	2	2	1	1	1	
G:		6	4	2	2	1	1	1	
G#:		6	4	2	2	1	1	1	
A:	6	6	4	2	1	1	1	1	
A#:	6	6	4	2	1	1	1	1	
B:	6	6	4	2	1	1	1	1	

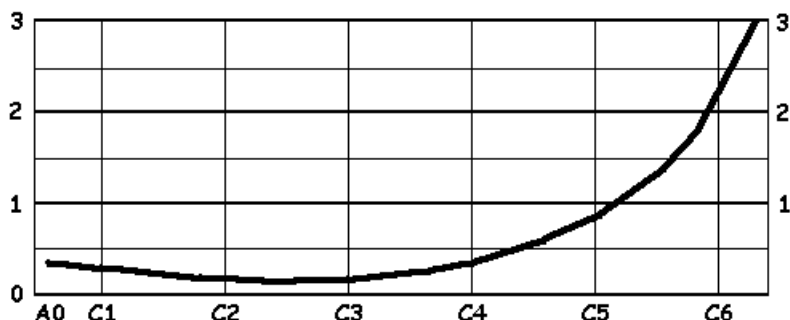
partial for the highlighted note. You can highlight a different note by clicking on the partial number for that note. Since the same partials are generally used by a group of notes, the **Duplicate** button is provided to duplicate the highlighted partial into the next note and move the highlight. In this manner you can quickly set an entire section of notes to the same partial.

The table of partials is stored along with the tuning curve in the tuning file when you save a tuning. So it is possible to customize the table of partials for each piano that you tune. Whenever you begin a new tuning, the table of partials is initialized from the special tuning file, **DEFAULT**, which is installed when you install TuneLab. If you want to make a change to the table of partials that will apply to all new tuning files that you create, then you can explicitly load **DEFAULT** as a tuning file, edit the table of partials, then save the modified **DEFAULT**, which will replace the original **DEFAULT**. Partial numbers can also be changed on-the-fly using the function keys **F3** and **F4**. These on-the-fly changes are not stored in the table of partials and are canceled when a new note is selected, unless you have enabled “Persistent Partial Numbers” under Edit Options, in which case changes made on-the-fly are immediately incorporated into the current tuning file.

Inharmonicity

Inharmonicity is the name given to the phenomenon whereby the partials of a piano string are not exact multiples of a fundamental frequency. TuneLab assumes that the partials are offset from their exact whole-number multiples of the fundamental by an amount that increases with the square of the partial number and is proportional to the inharmonicity constant for the given string. When TuneLab measures inharmonicity for a string, the pitches of all the partials of that string are analyzed and an inharmonicity constant is generated for that string. The inharmonicity constants are stored in the tuning file when a tuning is saved. You don't need to be concerned with the actual values of the inharmonicity constants that you measure; but you can see and edit them from the **Edit** menu. In a well-scaled piano you can expect to see the lowest inharmonicity constants somewhere in octave 2. From there the inharmonicity constants increase slightly as you move down to A0 and they increase substantially as you move up to C8, as shown below. TuneLab uses the specific samples that you

collect to find a best-fit inharmonicity model for the entire scale. Using this model, TuneLab makes all the calculations regarding how partials relate to one another.



Typical Inharmonicity Values for a Kawai Grand

Over-pull Mode

When raising or lowering the overall pitch of a piano by a significant amount, you will find that the notes that you tune first are changed by the time you are done tuning. This is due to the interaction of the string tensions, primarily through the bridge and soundboard and the flexing of the plate. When an entire section of notes is raised in pitch, the result is that the notes that were tuned first will tend to drop in pitch. Even the notes that you tuned last will drop somewhat due to the delayed settling of tension in the wire.

Over-pull tuning mode compensates for this change by setting tuning targets that are a calculated amount beyond the desired pitch. In this way the change that occurs will leave the notes right where you want them. In many cases using just one pass with over-pull tuning can take the place of tuning the piano twice. Over-pull mode accomplishes this goal by making a quick one-second pitch measurement before you start tuning each note. The collection of these measurements is called the “over-pull history”. The most recent portion of the history list is displayed to the left of the selected note as shown below.

Most recent	-43.3	G#5	Over-pull pulling from -41 cents
-41.4	-56.5		
-42.7	-50.9		
-51.8	-44.9		

The main purpose in displaying this list is to provide verification that the over-pull calculations are based on valid measurements. Sometimes during a pitch raise extraneous noise can trigger a false reading to be entered into the history list. The false reading can be corrected by re-measuring the current note. When in over-pull mode, the field normally used for the temporary offset is used to display the over-pull offset as shown earlier in the current settings. Temporary offsets are not permitted in over-pull mode (although you can use the basic offset for the same purpose). When over-pull mode is first entered you have an opportunity to adjust some parameters that affect how over-pull is calculated. The parameter that is most often changed is the over-pull percentage, and this can be done quickly while you are tuning using Functions keys **F7** and **F8**.

Calibration

TuneLab should be calibrated before you trust its absolute pitch. Without calibration, TuneLab assumes a nominal crystal oscillator frequency in its sound system and makes all pitch calculations from that assumption. By doing a calibration you are refining that nominal value based on a comparison to a trusted pitch source. You can do a rough calibration using a tuning fork, but your final calibration should be with some more precise source, such as the NIST phone service described later. The result of a calibration is a revision of the actual sample rate of the sound system, which is shown in the **About** box. Normally, calibration is done only once when TuneLab is first installed on your computer. See the chapter on calibration later in this manual for details on doing a calibration.

Hands-Free Note Switching

Using the menu or the keyboard you can enable different forms of hands-free note switching. There is **auto note switching**, which listens for and switches to nearby notes when it hears them. There is **timed note switching**, which switches to the next note after a certain delay time. And there is **Auto Measure**, which switches notes to sequence through a pre-defined list of notes that you want to measure for inharmonicity when starting a new tuning file. When any of these forms of hands-free note switching is in effect, note switches are performed just as if they had been done manually. The current note switching status is shown in the bottom center of the Current Settings box. . Auto Measure is initiated by starting a new tuning file. After the inharmonicity measurements are made, the note switching mode returns to whatever it was before.

In TuneLab Pro, the different forms for hands-free note switching are most easily enabled with the keyboard. Shift-Right-Arrow and Shift-Left-Arrow enable auto note switching in the indicated direction. Press both arrows at once to enable both directions. Alt-Arrows enable timed note switching. There are also menus for making these selections. Auto Measure is initiated by starting a new tuning file. After the inharmonicity measurements are made, the note switching mode returns to whatever it was before.

Auto note switching will switch up to three notes away from the current note. It can be enabled for up, down, or both directions. When over-pull mode is also enabled, or when higher treble notes are selected, auto note switching requires a “trigger”, which is a sudden rise in volume, such as you would get when playing a note after some silence. At other times, auto note switching is less demanding, and will switch when the pitch changes without a trigger event. If TuneLab doesn't switch when you want it to, wait for some silence, and then play the note again.

Timed note switching is useful primarily for doing a quick first pass pitch raise. You can set the delay time in Edit Options. If it is time to switch notes, but you are still playing the current note, then TuneLab will hold off doing the switch because it will not switch until it hears a brief period of silence. You can pause timed note switching by pressing the space bar.

Auto measure is the mode that TuneLab uses when you start a new tuning file, provided you have previously set up your list of preferred notes to measure under Edit Options. This mode is in effect only while you are measuring inharmonicity. After the last note in your list has been measured, auto measure mode is automatically canceled and the note switching mode returns to whatever it was before. After each note in your list is measured, TuneLab switches automatically to the next note in your list and starts the inharmonicity

measurement for that note. If you should abort any measurement, TuneLab will not do any more sequencing until you manually start another inharmonicity measurement.

Historical Temperaments

By default, TuneLab assumes an equal tempered scale. If you would like to tune in some unequal temperament, you can select an historical temperament file to apply to your tuning. An historical temperament file contains a list of 12 offsets for each of the 12 notes of an octave. When an historical temperament is selected, one of these 12 offsets is used, depending on which note is selected. For any given note, the same offset is used in every octave. In addition, the temperament offset may be optionally normalized. This means that all 12 offsets will be shifted by the same amount before they are used. You can choose to have the offsets normalized so that the offset for A is always zero; you can choose to normalize so that the average offset is zero (to minimize the overall change from equal temperament); or you can choose to use the historical temperaments just as they are with no normalization. The temperament name and the temperament offset for the selected note appear in the Current Settings box shown previously. When you save a tuning the historical temperament values (and temperament name) are saved in the tuning file. See the chapter on special functions for information on making and using temperament files.

Tuning Files

A tuning file is a file made by TuneLab and stored on your computer. In this file are all the factors necessary to re-create a specific tuning. You can save the current tuning to a named file, or open an existing tuning file from the **File** menu. You can also save a tuning file by clicking on the diskette icon in the toolbar. The tuning files are stored in a folder that you select during installation. That folder is either the **TLABPRO** folder under **Program Files**, or the **TuneLab** folder under **My Documents** (or wherever you keep your personal document files). If you want to organize your tuning files into several folders (like “Churches” and “Homes” or “Grands” and “Verticals”) under the one home folder, then you can create these other folders as you save tuning files. When you save a tuning file, you will see a standard Windows “Save As..” dialog box. The appearance of that box will depend on which version of Windows you are running. But all versions offer some way to select different folders and to create new folders. Examine all the elements of your “Save As..” dialog box and you will find a way.

Here is what a tuning file contains:

- The inharmonicity constants for all the notes that you measured.
- The adjustment settings of the tuning curve (the template).
- The name of the historical temperament (if any) and all 12 offsets from that temperament.
- The partial and custom offset (if any) for each of the 88 notes.
- The selection of bass and treble intervals in the tuning curve adjuster.

Sound Generation

Although the common use for TuneLab is in listening to notes and providing a visual tuning aid, you can also use TuneLab as a tone generator. When TuneLab is in sound generation mode, the spectrum display and

phase display are disabled. The pitch of the sound generated in the speakers is the same as the pitch that would have indicated correct tuning in the listening mode. The pitch is generated for whichever partial is selected - not necessarily the fundamental. Sound generation using low pitches may not be audible due to the limitations in the frequency response of the speakers found in laptop computers.

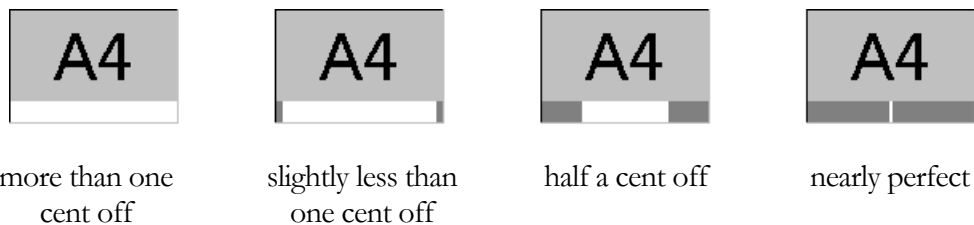
Sound generation is generally used to aid in stringing operations where precision is not as important as in normal tuning. If you intend to use sound generation for precise tuning in TuneLab Pro, you should be aware of the fact that some laptops use two separate crystal oscillators in their sound output and sound input operation. Therefore a separate calibration may be needed for the sound generation mode. If this is the case with your laptop, you should do the separate output pitch calibration as described in the chapter on calibration. Even if your laptop has only one sound crystal, it does not hurt to do a separate calibration for the tone generation. If you don't plan on using TuneLab to generate tones, then you don't need to do this special output calibration.

Note Selection

You can select a note by pressing the letter and then the octave number for the note on the keyboard. To select a sharp, use the right arrow key after selecting the natural, or use UPPER CASE letter to select the sharp directly. You can also select notes by using the right and left **Arrow keys** to move up and down the scale. You can change octaves with the **Page Up** and **Page Down** keys. During a normal tuning it is most convenient to switch notes automatically using **auto note switching**. During an extreme pitch raise, it may be more useful to use **timed note switching**.

Tuning Closeness Indicator

The current note display has a region on the bottom that indicates how close your tuning is to the target pitch. Here are some examples:




As these examples show, the gray bars start appearing when the tuning is within one cent of the target pitch; they close down and meet in the center at zero cents.

Normal Tuning Procedure

This chapter takes you step-by-step through an ordinary piano tuning (not a pitch-raise). We are also assuming that you have not tuned this piano before and saved a tuning file, because if you had, then you could skip the initial setup and just load that tuning file now and begin tuning.

Initial Setup

Tuning with an electronic tuning aid can be done with just two mutes. First check the condition of the existing tuning to see if there are any major problems with the piano and to see if a pitch raise is necessary. Assuming that a pitch raise is not necessary, the next step is to measure the inharmonicity of the piano.

When TuneLab is started it will have a tuning file name such as “untitled-1”. If you have some other tuning file loaded as the current tuning you should clear out that tuning and start a new tuning by selecting the toolbar  button shown here. This will clear out any old inharmonicity constants and reset the table of partials to the default. You are now ready to develop a new tuning. If you had previously specified the option of automatically sequencing through a set of notes, then TuneLab will now switch to the first of those notes and start the inharmonicity measurement.

Measuring Inharmonicity

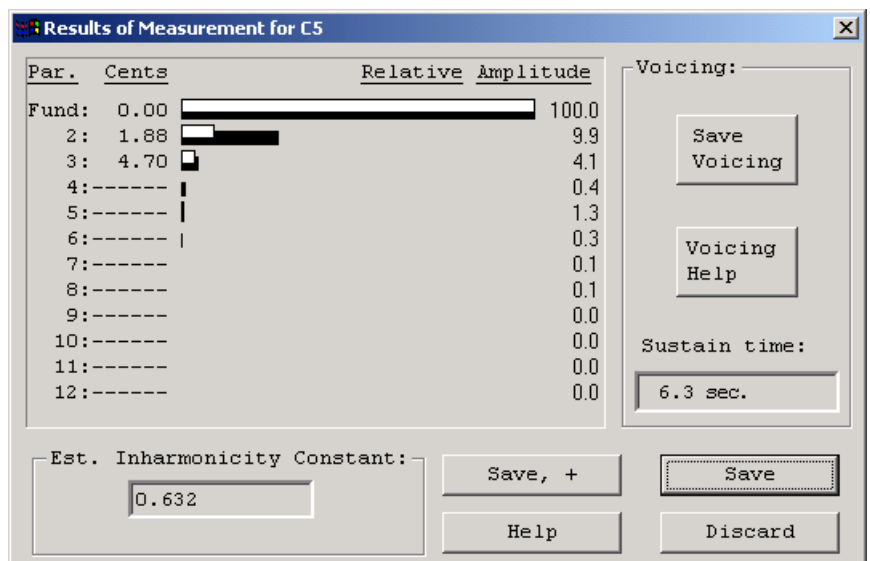
Start by measuring the inharmonicity of at least four notes and preferably six notes. If the piano is a spinet that is known to have a large break in the inharmonicity, you may want to consider using the Split Scale mode, as described in the Special Functions chapter. For now, we will assume that the piano is a well-scaled instrument that does not require Split Scale mode. We will measure the C notes from C1 to C6. If one of these notes is hard to measure accurately because of a serious false beat or lack of partials, then just measure some other nearby note instead. The graph in Chapter 1 shows typical inharmonicity measurements of a Kawai 6'8" grand. In any case, when you measure the inharmonicity of a note you should mute all but one string of the note. Measuring the inharmonicity of two or three strings sounding at once is not recommended.

To measure the inharmonicity of a note, select that note in TuneLab, as described in Chapter 1 under “**Note Selection**”. (That selection may have been done for you if you had set up an auto measure sequence in Edit Options.) Now that TuneLab is showing the note that you want to measure, if the measurement has not already been initiated by the auto measure sequence, begin a measurement by pressing **M** on the keyboard. This will cause a status box to appear showing “Measuring, waiting for trigger”. TuneLab will begin listening to the note as soon as you play it. The sudden rise in sound level is the trigger. If you do not play the note shortly after initiating a measurement it is quite likely that some extraneous noise may trigger the sampling period and you will get a false reading. If this happens, just wait for the calculation to finish and then discard the reading

and start over. If the “**Auto Measure**” option has been enabled, then you do not need to switch notes or start each measurement because this will be done automatically for you.

When sampling for inharmonicity you should play the note that you want to measure and then watch the status box change from “**waiting for trigger**” to “**listening**”. This listening period is about six seconds for low notes and progressively shorter for higher notes. If the piano is in good condition the sustain period of the note should last to the end of the “listening” period. After the listening period is over the status display will switch to “**calculating**”. At this time you can stop holding the note because TuneLab is no longer listening to it. TuneLab will then display the results of the measurement. In some notes with too-soft hammers, the partials are so weak or ill-defined that they cannot be measured. In that case it may be useful to pluck the string rather than strike it using the key. If you pluck the string, pluck it near the termination point to get a rich set of partials. This is generally needed only for very high notes.

The most important measurement is the inharmonicity constant. The graph in Chapter 1 shows the typical pattern of inharmonicity constants for a Kawai 6’8” grand (model 650). Other pianos may have more or less inharmonicity, but the pattern should be approximately the same. The graph stops at C6, but in almost every case, the actual inharmonicity continues in the same pattern of rising inharmonicity established by the lower octaves. So you can avoid measurements in the highest octaves and still have an accurate picture of the inharmonicity of the piano.



When a measurement is complete, TuneLab displays a box like the one shown to the left. Here we see that pitches were detected for the fundamental and partials 2 and 3. Some of partials 4-6 were detected, but they were too weak to be used for measuring inharmonicity. The offset column shows the offset in cents for the individual partials as compared to what they would be if there were no inharmonicity. Generally there is more inharmonic offset the higher you go in the partial series. The amplitude column shows the relative strengths of the specific partials. TuneLab


analyzes the pattern of partial offsets and calculates an inharmonicity constant for the string - in this case 0.632. If things look reasonable at this point then you would select **Save**, which will save the inharmonicity constant for the note C5. You can also select **Save,+** which will save the measurement and then begin another measurement of the same note so that you may average several readings of one note. This is especially useful when using the auto-measure sequencing where **Save,+** will allow you to take additional readings of the same note without canceling the auto-measure sequence. In this box you can also view the partial amplitudes in graphical form using the horizontal bar graph, which is explained in Chapter 6 in the section on Voicing. If you measure inharmonicity again for the same note, the inharmonicity readings will be averaged.


Adjusting the Tuning Curve


Now that the inharmonicity readings have been taken, TuneLab forms a model of the inharmonicity of all the notes of the scale, not just the notes that you measured. Using that model, TuneLab can predict how various intervals will sound. You can use that prediction to find an adjustment of the tuning curve that suits you. This tuning curve is sometimes called the template tuning curve because it follows a four-parameter template.

Subjective value judgments can play a role in how tuning curve adjustments are made. Normally we recommend fully automatic adjustment mode, which you can select using the toolbar buttons at the top of the adjuster screen. When the fully automatic mode is selected, you can cause the automatic adjustment to be made by pressing **U** on the keyboard, or clicking on any of the four **Auto** buttons below the tuning curve.

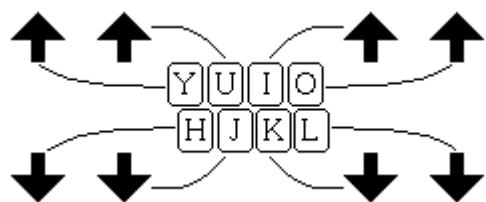
Refer to the picture of the tuning curve in Chapter 1. You get to this screen by pressing **T** on the keyboard or by clicking on the tuning curve icon in the toolbar. You are also taken to this screen automatically at the end of a sequence of inharmonicity measurements for a new tuning. Note the buttons that select between the three different ways of adjusting the tuning curve;

 This button selects the totally manual method of adjusting the tuning curve. When this option is used, you must use the adjuster arrows to adjust all four aspects of the tuning curve, which are overall stretch in the treble and in the bass, and the shape of the bass and treble portions of the curve.

 This button selects the semi-automatic method. The overall stretch in the treble and the bass are calculated automatically, but you must manually adjust the shape of the treble and the bass using the remaining adjuster arrows.

 This button selects the fully automatic method. All four aspects of the tuning curve are adjusted automatically when you touch any of the adjuster arrows, which now will say “Auto” instead of showing a picture of an arrow.

If you do not choose the fully automatic method, then you must use some or all of the adjuster arrows below the tuning curve. The arrows at the extreme left and right control the overall stretch in the bass and the treble. The inner arrows control the shape of the bass or treble portion of the tuning curve without changing the overall stretch.



Although tuning curve adjustments can be carried out using the mouse, it is generally easier on laptops to use the equivalent keyboard keys for these actions. The mappings shown to the left are effect. This mapping shows the inner four adjuster arrows mapped to U, I, J, and K. These four arrows are the only adjuster arrows that you normally will see. The outer four adjuster arrows which map to Y, O, H, and L are only visible if you select the option to manually adjust the endpoints of the tuning curve. If the semi-automatic adjustment method is selected, then the outermost arrows will disappear leaving only the inner arrows (U, I, J, K on the keyboard) to be adjusted. And if the fully automatic method is selected, the inner arrows become “Auto” adjustment buttons. If you are using the fully automatic method of tuning curve adjustment, then you can skip the adjustment details.

Whether you click on the arrow buttons or use the equivalent keys, the amount by which these adjuster buttons change the tuning curve varies depending on how the buttons are used. If you hold any button down the amount of adjustment increases faster and faster the longer you hold down the button. If you change between up and down the amount of adjustment decreases. So if you want the adjustment to proceed faster, just hold down the desired button (or its equivalent key on the laptop keyboard). If the adjustment is too fast, then you will probably overshoot your goal, so you naturally will change to the opposite adjuster arrow. Doing so will reduce the size of the adjustment, so that you can adjust as finely as you want merely by changing directions. To become familiar with how this all works, now might be a good time to experiment. Try holding down one of the adjuster arrows until the adjustment reaches its limit and the word “limit” is displayed in place of the arrow. Then hold down the opposite direction arrow until the adjustment reaches the limit in that direction. Notice how a portion of the tuning curve moves as you vary the adjustment. Now experiment with single taps on the adjustment arrows. Change direction several times. Notice how the adjustment becomes finer and finer.

In the course of doing an adjustment you may find that a portion of the tuning curve goes off the scale. If this happens and you want to see the whole curve, press the **Z** key (for “Zoom”). This will toggle the graphical limits between the original limits and the limits that exactly contain the current curve.

Now that you have become familiar with the mechanics of adjusting the tuning curve, it is time to adjust the tuning to match your tuning criteria. You may want the 6:3 octaves in the low bass to be as pure as possible and the 4:1 double octaves in the treble to be as pure as possible. Do that by selecting these intervals in the selection boxes located around the adjuster arrows. Open these drop-down selection boxes by clicking on the little triangle after the interval name. Scroll through the choices and tap or click on 6:3 in the left selection box and 4:1 in the right selection box. TuneLab will remember your preference and these intervals will always be selected for you when you start a new tuning. In addition, the interval selections for each tuning will be stored in the tuning file, so you can have different interval selections with each tuning file.

Now that you have the proper intervals selected, the deviation curve (the lower curve) shows you how your selected intervals will sound. The goal is to adjust the tuning curve until the deviation curve is as straight as possible at both ends. This is, in fact, what the fully automatic adjustment method does. You will notice that the right-hand adjuster buttons control the shape of the treble end of the tuning and hence the shape of the treble end of the deviation curve. If the deviation curve is bowed up in the middle, press the down adjuster arrow. If the deviation curve is bowed down in the middle, press the up adjuster arrow. Unless you are using the totally manual method, the ends of the deviation curve will always be at zero. Your goal in adjusting the shape is to get as much of the deviation curve as possible to lie close to zero.

When you adjust the shape of the bass end of the tuning curve you will notice that the deviation curve moves in the opposite direction as the tuning curve. This behavior is a consequence of the way the deviation curve is defined. If the bass end of the deviation curve is bowed up in the middle, press the up adjuster button. If the bass end of the deviation curve is bowed down in the middle, press the down adjuster button.

The Zoom function was mentioned earlier in relation to containing the tuning curve. The Zoom function also scales the graphical display of the deviation curve.

When you get the deviation curve to look something like the one shown in the picture in Chapter 1, then you are done. Notice that the deviation curve does not hold very close to zero at the transition in the middle. That

is normal and expected. As you move from the bass to the treble, your criterion for a good tuning gradually changes from making 6:3 octaves beatless to making 4:1 double octaves beatless. Midway through that transition the 6:3 octaves will be a little narrow and the 4:1 double octaves will be a little wide. It is impossible to get both intervals to be beatless at once throughout the scale. You should find that in the vicinity of the transition you have other criteria for a good tuning (such as 4:2 single octaves) and those criteria will be satisfied quite well. The criteria for a good tuning that we suggested here are just a starting point. Some TuneLab users report getting better results by selecting 4:2 octaves in the treble. Feel free to experiment to find the settings that most closely correspond to your tuning style.

Saving the Tuning File

After the tuning curve has been adjusted to your satisfaction, exit from the tuning curve adjuster by pressing **ESC**. If you want to save this tuning file for later recall, now would be a good time to do so. Save the tuning file by clicking on the Save Tuning File icon (the diskette image) in the toolbar and entering the name of the tuning file. Use a name that is short enough to fit in the space allotted in the current settings box but long enough to remind you which particular piano this is so that you can recognize it in a list of other tuning files. If you are tuning a lot of new pianos of the same brand you may decide to keep one tuning file that you use for all pianos of a particular model. If you have the time, it is best to measure inharmonicity and adjust a tuning curve for each piano. However new pianos of the same model do not vary that much and for all but the most critical uses, a generic tuning may be acceptable. You can delete tuning files from the Open File box using the right mouse button. See Chapter 1 for information on organizing your tuning files into different folders. After saving a tuning file, you can enter comments about this tuning from the **View** menu. The comments will be placed into a text file with the same name as the tuning file.

Beginning to Tune

Now that you have a custom tuning file for this piano and that tuning file has been saved, you can turn your attention to actually doing the tuning. Because aural tuning always starts by setting a temperament, aural tuning sequences start in the middle of the scale and work downwards and upwards from there. When tuning to a calculated TuneLab tuning file, you need not conform to this sequence. You can tune in any order that you want. Although you may not be considering a pitch raise at this time, remember that you will get less interaction between notes if you tune from the low bass to the high treble in order. That is the recommended sequence. However there is at least one possible advantage to tuning the treble first. Tuning the treble requires more concentration and it might not be a good idea to leave the treble to the end when you may be tired. In any case, the decision on the tuning sequence is yours to make.

If tuning the bass first, select A0. Play the A0 on the piano and watch for a peak on the spectrum display. The bass requires some special consideration. Because you are tuning to a high partial, it is quite easy for a wrong partial to masquerade as the correct partial if the note is seriously mis-tuned. When in doubt, use aural methods to verify that the note is at least in the ballpark before trusting the spectrum display or the phase display. If you do not see a very prominent peak in the spectrum display, it is not necessarily a cause for concern. The phase display will work even with partials that are almost too small to see in the spectrum display. Especially in the bass, feel free to select a different partial on the fly if you are having trouble getting a reasonable indication on the current partial. You can press Function keys **F3** or **F4** to change the partial. If you have enabled auto

partial selection in Edit Options, then TuneLab will search for a stronger partial as you tune and switch partials automatically if one is found.

We recommend that for your very first tuning with TuneLab you leave auto note switching disabled. That way you will not be confused by unintentional note switches. Later on, you can enable auto note switching to speed up your tuning. For now you can manually switch notes by pressing the arrow keys.

When you finish the monochord section of the bass and come to the bichords, always mute one of the strings before tuning the other string in the unison. After one string is tuned, remove the mute and tune the unison aurally. There are times when machine tuning of the unisons is an advantage, but those instances are usually in the high treble. In the bass there are many partials that need to be balanced. Tuning these unisons aurally allows you to make the needed compromises to get the best-sounding unisons. Also, aural unison tuning is faster than using the machine.

Proceed up through the bi-chords and into the tri-chords. Here you can mute the outside two strings and tune the middle string. Then move the right mute over one note to expose the right-hand unison. Tune that unison aurally and then move the left-hand mute over one note. That will expose the left-hand unison and also re-mute the right-hand string. In case your right-hand unison was off at all, it is better to tune the left-hand unison to the middle string than to tune the left-hand unison to the combination of the middle and right-hand strings sounding at once. Also, having all three strings sound at once increases your chances of having to deal with false beats. So always tuning unison strings in pairs is recommended.

Continue tuning through the high treble. Here you may have some trouble with the phase display. Even though TuneLab has artificially slowed down the movement of the phase display in the high treble, false beats together with a short sustain can produce a confusing picture in the phase display. It is here that we recommend that you switch over to using the spectrum display. The resolution of the spectrum display is in terms of cycles per second, not in terms of cents. Therefore the cents-wise resolution of the spectrum display gets better and better the higher you go in frequency. You can see this by noting the jagged look of the spectrum display around A-440 in the picture in Chapter 1 as compared to the somewhat more precise look of the graph following that one which is based around C7 (at about 2100 Hz). Therefore, in the high treble we recommend just trying to get the peak to be centered on the central red line in the spectrum display.

Using Auto Note Switching

You can use auto note switching to make tuning easier. To enable this feature hold the Shift key and press the appropriate Arrow keys. When auto note switching is enabled, TuneLab will be constantly listening for nearby notes; and when it hears one, it will switch to it. Auto note switching can be enabled for switching up, down, or in both direction. The range of auto note switching is up to 300 cents from the current note. If you use aural checks while tuning, be aware that auto note switching may occur while you are doing these checks. If an unintended auto note switch occurs, simply use the arrow keys to return to the correct note.

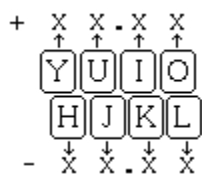
When over-pull mode is also enabled, or when higher treble notes are selected, auto note switching requires a “trigger”, which is a sudden rise in volume, such as you would get when playing a note after some silence. At other times, auto note switching is less demanding, and will switch when the pitch changes without a trigger event. If TuneLab doesn't switch when you want it to, wait for some silence, and then play the note again.

All About Offsets

TuneLab uses various offsets. The offsets are all displayed on the right side of the Current Settings box, as shown in Chapter 1. TuneLab combines them to calculate the desired pitch for each note. In normal tuning, only the template tuning curve offset is used and the other offsets are all zero. These offsets can be entered numerically using the **Enter Current Settings** menu item, or by pressing **F6**.

Temporary Offset (or Over-pull)

This is either the “temporary” offset (also just called the “Offset”), or the “over-pull” offset in over-pull (pitch-raise) mode. When TuneLab is not in any special mode, you can adjust this offset in a variety of



ways. As shown on the left, you can adjust the offset using the keyboard keys **Y**, **U**, **I**, and **O** to raise the offset by +10, +1, +.1, and +.01. Similarly, the keyboard keys **H**, **J**, **K**, and **L** may be used to lower to offset by -10, -1, -.1, and -.01. The **Z** key will set the offset to zero. You can transfer the Offset to the custom stretch for the current note, or you can transfer it to the Basic Offset using menu items or function keys. In over-pull mode, this offset is replaced by

the over-pull amount, which is not manually adjustable, but it is calculated automatically. In preparation for a Tuning Exam, this field shows the detuning offset when the detuning mode is selected. The temporary offset can also be affected by Locking mode, which is described later in this chapter.

Custom Stretch

This is an optional note-by-note offset and it is stored in the tuning file. It is rarely used, except when recording an aural tuning for the Tuning Exam. It can be used to make note-by-note corrections to the tuning curve. But if you find yourself making many such corrections, then you should consider readjusting the whole tuning curve instead. This custom stretch can be set by a transfer from the temporary offset as described above. This offset is not displayed if it is zero.

Template (Tuning Curve) Stretch

This offset comes from the tuning curve. It is calculated based on the adjustment of the whole tuning curve, taking into account the partial that is selected and the inharmonicity. The only way it can be adjusted for any one note is to adjust the tuning curve as a whole.

Temperament Offset

This offset is shown only when a un-equal (historical) temperament is selected. In that case, this offset shows the temperament offset for the current note, which is the same for all other notes of the same name in different octaves. The 12 temperament offsets are stored in the tuning file when it is saved with an un-equal temperament selected.

Basic Offset

This offset used to offset the tuning as a whole. It is most commonly used to change to a non-standard pitch, such as A-442. Its effect is just like that of the temporary offset, except that it is not so easily changed. You can transfer the temporary offset to the Basic Offset by pressing Shift-F9. Zero the Basic Offset by zeroing the Offset with the **Z** key, and then transferring the Offset to the Basic Offset.

Locking Mode

Locking mode is entered by pressing the period (“.”) key. Then shows a status box that says “**waiting for trigger?**”. A trigger is a sudden rise in volume as you would expect when a piano note is struck. If TuneLab does not hear a trigger, you can force one by pressing the period key again.. To cancel locking mode, press the **ESC** key. When Locking mode is active, the offset is automatically adjusted by TuneLab to make the phase display come to a complete stop. The adjustment starts by making large rapid changes in the offset, which gradually reduce to a small slow changes after a few seconds. This behavior allows quick initial locking, followed by more precise offset trimming as the feedback is reduced. When the aggressiveness of the locking action is gradually reduced, the offset will not wander as much and a more accurate reading can be taken. At any time during the locking operation the aggressiveness of the offset adjustment can be reset to its initial maximum value by pressing the period key again.

Entering Offsets for a Specific Frequency

In the **Enter Current Settings** box, there are three offsets that are normally specified in terms of cents. These are the offset, the custom stretch for the current note, and the basic offset. When entering values in these fields, instead of entering a number in cents, you can enter a frequency in Hz in the following formats:

A=442 (for offset or basic offset)

F=524.35 (for offset, custom stretch, or basic offset)

In both of these formats, the ‘=’ sign is optional and may be omitted. Also the letter ‘**F**’ or ‘**A**’ may be entered as lower-case ‘**f**’ or ‘**a**’ as well. If the entry starts with letter ‘**A**’ then the number afterwards is interpreted as the desired pitch in Hz of the note A4 (instead of the standard 440). The offset being specified will be set in cents to whatever is needed to make A4 have the specified pitch. The effect of this entry is the same regardless of what note is currently selected on the main tuning screen. If the entry starts with the letter ‘**F**’ then the number afterwards is interpreted as the desired pitch of the currently selected note and partial. In the example above, we might be specifying the pitch of C5, provided that C5 is the note that is selected on the main tuning screen at the time that this entry is being made.

Over-pull (Pitch Raise) Tuning Procedure

Over-pull tuning is sometimes called pitch raising. When large overall changes are made to the tuning of a piano, the notes that you tune first tend to change as you tune later notes. Over-pull tuning mode compensates for this change by setting the pitch a calculated amount beyond the desired pitch. In this way the settling that occurs as later notes are tuned will leave the notes right where you want them. In many cases using just one pass with over-pull tuning can take the place of tuning the piano twice.

Measuring Inharmonicity Before an Over-pull

When over-pull mode is activated you cannot measure inharmonicity. Therefore if you want to create a custom tuning for the piano as described in the Chapter 2, you must measure the inharmonicity and adjust the tuning curve before enabling over-pull mode. For small to moderate pitch raises, the normal inharmonicity measurements will be sufficient. However, for extreme pitch raises, the act of pulling the string up to pitch will change its inharmonicity. For such pitch raises, you are not going to get away with doing a one-pass tuning anyway. So when you do the second pass, discard the old inharmonicity readings by starting over with a new tuning file, and take fresh inharmonicity readings. In fact, you would probably be better off skipping the inharmonicity readings on the first (extreme) pass and using a generic tuning file from a similar model piano for that pass. Then only the final pass needs to be customized.

Enabling Over-pull Mode

If your pre-tuning evaluation of the piano convinces you that the overall pitch change is large enough to need an over-pull, then you can enter over-pull mode by using the over-pull icon in the toolbar or by pressing Function key **F2**. A dialog box like the one shown here will open up. Most of the time all you need to do at this point is select **Begin**, but you can also use this opportunity to set various preferences relating to over-pull. TuneLab will remember your settings so you need only to enter them once. If you are not going to change any of the settings, just select **Begin** and skip ahead to the next

Over-pull Preferences

Absolute upper limit on over-pull:

Up to **A#2** use no more than **5 cents**

Above that note use no more than **25 cents**

Current over-pull percentage: **25**

Over-pull amount is determined by the previous **7** notes.

Measure every note Instant measuring

Measure notes only on command

Assume offset

Cancel

Clear history list (Avg= 0.0)

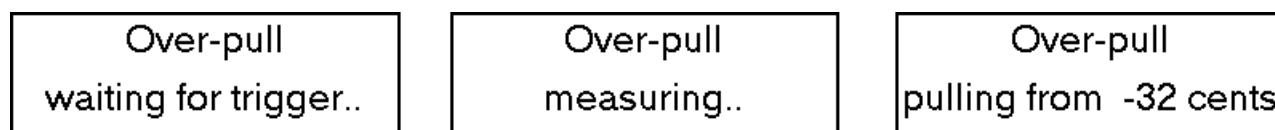
Begin using over-pull

section on Beginning Tuning in Over-pull Mode.

The first group of fields sets safety limits for over-pull in cents. You can change these entries by clicking on the small triangle in the drop-down selection boxes. The purpose of these overriding limits is to reduce the likelihood of breaking strings in an extreme pitch raise. These limits do not come into play in small to moderate pitch raises. They define the maximum over-pull in cents for two groups of notes. If the calculated over-pull is higher than the limit shown here, then TuneLab will use the specified limit value and not the calculated value for over-pull. The other items in this dialog box are explained later.

Beginning Tuning in Over-pull Mode

Before each note is tuned in over-pull mode, TuneLab can listen to the note for one second to get a rough measurement of its pitch. TuneLab keeps this information in a history list as described in Chapter 1, and uses this information to calculate the over-pull offset. You can follow your progress through the over-pull sequence by watching the status box that appears in Over-pull mode. Here is what you would see as TuneLab waits for you to play the note, listens for one second, and then displays the results, at which time you can begin tuning the note:



The first status box on the left is what you would see after changing to a new note or after requesting a re-measuring of the current note. When you play the note you will see the second status box followed briefly by the third status box which will show what the measurement was for the current note. When you see the third status box you may then begin to tune the current note in the usual manner. If it appears that TuneLab does not always recognize when you play a note to be measured, remember that TuneLab is triggered by a sudden rise in volume. You should have a short break in the sound before striking the note so that TuneLab will see a clear difference between the silence and the sound of the note being struck. Then it will begin the measurement.

If the measurement shown in the third status box looks unreasonable, then perhaps an extraneous sound triggered the measurement before you actually played the note. If that is the case you can re-measure the current note by using the measure icon in the toolbar or by pressing the **M** key. Every time you request a re-measuring of the current note, the most recent measurement is removed from the history list and TuneLab returns to waiting for you to play the note again. If you somehow get several bad readings in the history list, you can remove as many entries as you like by repeatedly pressing **M**.

Faster Pitch Raising

To get the most accurate over-pull tuning, TuneLab normally measures every note automatically before it is tuned. One way to speed up the process is by measuring only occasionally, by selecting the “Measure notes only on command” option shown above. When automatic over-pull measurement is disabled in this way, you decide when a note should be measured by explicitly starting an over-pull measurement as described above.

For those notes that you don't bother to measure, TuneLab will assume the same measurement for that note as for the previous note, and you can go directly to tuning as soon as you change notes.

Another way to do a very fast pitch-raise is to use timed note switching, as described in Chapter 1, and do a rough tuning only. Timed note switching will keep you from spending too much time on one note. You can tune without mutes and use the spectrum display, tuning roughly by moving the peaks for each string quickly to the red line in the middle. This will be close enough for a rough first pass. If you have the time delay set to 9 seconds, then you can complete the first pass tuning in about 13 minutes. If over-pull is used on this first pass, then perhaps the second pass can be done in normal mode.

How Over-pull is Calculated

You do not need to understand the exact formula for over-pull to take advantage of over-pull mode. TuneLab performs the calculation automatically based on the history list. The history list is the list of measurements taken before each note is tuned. The list is ordered from most recent to oldest. Only the most recent few measurements are displayed, but these recent measurements are the most important.

The over-pull amount is an offset in cents that is added to any other offset or stretch values. The over-pull amount is displayed in the upper right corner of the current settings box in the place normally used to display the temporary offset (if there is one). Note: The use of the temporary offset is not permitted in over-pull mode. If you must use an overall offset in over-pull mode, use the Basic Offset. The over-pull amount is calculated by starting with the most recent few measurements in the history list. How many are actually used is determined by the number that you have selected in the box shown when you first enabled over-pull mode. By default TuneLab uses the last seven notes. Assuming that seven measurements are used, TuneLab takes a weighted average of these seven measurements using weightings that give the most weight to the most recent measurement and progressively less weight to the older measurements. Finally TuneLab multiplies the weighted average by the over-pull percentage and uses the opposite of that number as the over-pull in cents (subject to the safety limits, of course).

Changing Over-pull Percentage

The over-pull percentage may be changed as you tune in over-pull mode. To make such changes fast and easy, use the **F7** or **F8** keys. The initial default over-pull percentage is 25%. The current over-pull percentage is always displayed in the current settings box when you are tuning in over-pull mode. For small to moderate pitch raises, simply use 12% when tuning in the bass bridge and 30% when tuning elsewhere. For more precise control of the tuning, use the following guidelines for over-pull percentage. These guidelines assume that you will tune unisons as you go up the scale from A0 to C8.

bass bridge	12%
tenor bridge to G5	29%
G5 to G6	29% increasing to 37%
G6 to C8	37% decreasing to 14%

Using Auto Note Switching with Over-pull Mode

There are some special considerations that need to be taken into account when using these two features together. If a pitch raise is more than 50 cents, the next note will sound closer to the current note, and TuneLab will not recognize it as the next note. In that case, consider using timed note switching, as described in Chapter 1. But assuming that auto note switching is feasible, it requires a “trigger” to switch, which is a sudden rise in volume, such as you would get when playing a note after a brief period of silence. This is to reduce the chance of mistaken note switches in over-pull mode. If an unintended note-up switch does occur, and if you correct it by manually switching back down to the previous note, then TuneLab will automatically remove any over-pull measurements that may have been entered into the history list after the mistaken auto note switch. Also, there is an option called “Instant Measuring” in the over-pull dialog box. If you check Instant Measuring, then the sound that triggers an auto note switch will also be measured automatically for the over-pull calculation. If you do not check Instant Measuring, then you will need to play the note once to switch notes and again to measure it. Then you can start tuning the note.

Saving the Entire History List

After tuning a piano in over-pull mode, the entire collection of over-pull pitch measurements made before each note was tuned may be saved to a file for later off-line study. From the File menu in TuneLab Pro, select Save Over-pull Measurements. You will be prompted to enter a file name. The entire history list will be written in text format to the file that you specify. The average of all the over-pull measurements are shown in the over-pull dialog box by the “Avg. = x.x” field.

When to Tune Unisons in a Pitch Raise

There are two schools of thought when it comes to this issue. You can tune unisons as you go, or you can use a strip mute and postpone the tuning of unisons until the end. Aside from any general considerations that may enter into your decision of which way to choose, there are special considerations relating to Over-pull mode.

Over-pull works by estimating how far the pitch of a string will fall as the rest of the piano is tuned. The current note is then tuned sharp by that same amount. If you tune unisons as you go, the notes below the current note will all have been tuned and the notes above it will not have been tuned yet. Therefore the current note will be affected only by the subsequent tuning of the notes above it. On the other hand, if you use a strip mute and postpone tuning unisons, the outer strings of the notes below the current note will not have been tuned yet. Therefore the current note will be affected both by the tuning of notes that lie above the current note and by the tuning of the unisons of the notes that lie below the current note. This subjects the current note to the almost twice as much pitch-fall after it is tuned. To compensate for this extra expected drop in pitch, you would have to use a higher over-pull percentage.

The guidelines shown for over-pull percentage are based on the assumption that you will tune unisons as you go. If you want to use a strip mute and tune unisons later, then plan on using a somewhat higher over-pull percentage. Warning! This may increase the chance of breaking strings on extreme pitch raises. Use the over-pull safety limits to prevent extreme over-pull.

Calibration Procedure

Chapter 1 described the need for calibration. This chapter takes you through the process of actually doing a calibration. Normally you need to do a calibration only once when you first install TuneLab on your computer. The results of the calibration are stored permanently and used every time you run TuneLab.

A Trusted Source of Pitch

To do a calibration you need to have a trusted source of pitch. The most accurate source of pitch that you can get is the National Institute of Standards and Technology (NIST). This agency of the U.S. government has a telephone service and shortwave radio service that disseminate standard time and frequency. The telephone service is free of charge (after you pay the normal long-distance charges), and the shortwave radio service may be heard on 2.5, 5, 10, 15, and 20 MHz. Another source of accurate pitch is a Sanderson Accu-Fork or Accu-Tuner. In most areas of the U.S. the telephone dial tone contains an A-440 that might be used for calibration, but this frequency is not certified by the phone companies and may be in error. You could even use a good tuning fork to do the calibration. The procedure described here involves the use of the NIST standard frequency service.

NIST Broadcast (and Telephone) Schedule

The NIST standard frequency service is broadcast on shortwave radio station WWV on the frequencies listed above. The audio portion of this broadcast is also available by telephone by calling (303) 499-7111 in Colorado. This is a very popular number. NIST reports that they get over two million calls per year. In order to use these services effectively, you need to know something about the schedule for WWV. The following schedule is followed each hour. It shows what tones are present during each minute of the hour. When a tone is present, it is present for the first 45 seconds of the minute and it is silent for the last 15 seconds.

0: ---	10: ---	20: 500	30: ---	40: 500	50: ---
1: 600	11: 600	21: 600	31: 600	41: 600	51: ---
2: 440	12: 500	22: 500	32: 500	42: 500	52: 500
3: ---	13: 600	23: 600	33: 600	43: ---	53: 600
4: ---	14: ---	24: 500	34: 500	44: ---	54: 500
5: 600	15: ---	25: 600	35: 600	45: ---	55: 600
6: 500	16: ---	26: 500	36: 500	46: ---	56: 500
7: 600	17: 600	27: 600	37: 600	47: ---	57: 600
8: ---	18: ---	28: 500	38: 500	48: ---	58: 500
9: ---	19: 600	29: ---	39: 600	49: ---	59: ---

Although the 440 Hz tone in minute #2 is tempting, do not try to use it. That pitch is only present for 45 seconds each hour. The difficulty in calling at just the right time and the shortness of the tone make this choice inadvisable. Instead you can use the 500 Hz and 600 Hz tones. The telephone service will disconnect you after three minutes, so make sure that when you call you have everything set up and time your call so that you will be assured of at least three minutes of 500 Hz or 600 Hz tones. If you happen to be closer to Hawaii than to Colorado, you can receive WWVH by shortwave radio or by calling (808) 335-4363 in Hawaii. For more information on both of these sources, see the website:

www.boulder.nist.gov/timefreq/stations/iform.html

Special NIST Tuning File for Calibration

To use the NIST standard frequency service to do a calibration on your TuneLab, start by opening the tuning file **NIST-303-499-7111-C5-D5** which was installed with TuneLab. This tuning file contains special custom stretch offsets for the notes C5 and D5 so that they come out to 500 Hz and 600 Hz respectively. The name of the tuning file also contains the Colorado phone number for the NIST service as a reminder. If you select C5 and then D5 you can see the frequency reported as 500 Hz and 600 Hz to correspond with the tones from NIST. Do not make any changes to this special tuning file, and of course do not try to tune a piano with it!

Manual Locking onto NIST

When TuneLab begins listening to an NIST tone, your goal is to trim the offset of TuneLab so that the phase display is perfectly stopped. There are two ways to do this - manually and automatically. The manual method is more accurate but the automatic method may be quicker to use. In either case, you will have to select C5 or D5 depending on which tone is coming from NIST. Don't bother trying to figure out which tone is present from the broadcast schedule. Just use trial and error. Select C5. If the spectrum display doesn't show a peak near the central red line then you probably have the wrong note, so switch to D5. If you run out of tone before you can get the phase display stopped, then switch to the other note because the 500 Hz and 600 Hz tones alternate each minute.

Trim the Offset as described in the Chapter "All About Offsets". While TuneLab is listening to the NIST tones from the telephone, the goal is to make the phase display be absolutely stopped by adjusting the offset to within a small fraction of a cent. Adjusting the offset by .01 cents will produce a change so small that you will not be able to tell that anything has changed unless you observe the phase display for more than 15 seconds, so don't worry about getting that last hundredths place right unless .01 cent absolute tuning accuracy is really that important to you. For most purposes, .05 cents is close enough. If the phase display is moving to the right, then you should make the offset higher (press **U**, **I**, or **O**). If it is moving to the left, then make the offset lower (press **J**, **K**, or **L**). The slower the phase display moves the finer the adjustment that is needed. When the phase display is as stopped as you can make it, you are done with the adjustment (but not with the calibration). You may hang up the phone at this point and go to **Completing the Calibration**.

Automatic Locking

As an alternative to the manual adjustment of offset that was just described, you can use the Locking mode in TuneLab, as described in the chapter "All About Offsets". When this mode is active, TuneLab listens to the

sound coming in and automatically adjusts the offset to make the phase display come to a complete stop. The process is somewhat sensitive to noise; but the automatic locking mode may be easier and faster. When locking to a tone on the telephone, there may not be a rise in volume sufficient to be detected as a trigger. You can force Locking mode to become active without a trigger by pressing the period (“.”) key again.

When Locking mode is active (as indicated by the Locking status box) the adjustments to the Offset will proceed continuously, and you should see the results of that adjustment in the upper right of the Current Settings box. If the sound that TuneLab is supposed to lock to is interrupted, TuneLab will continue to attempt to lock onto whatever sound it hears. If it hears just normal background noise, the offset will seem to change randomly. Therefore it is important to disable Locking mode before removing the tone. In the case of the NIST tones, if the tone stops before you have achieved a satisfactory lock, then you should disable Locking mode as soon as possible (by pressing **ESC**) and wait for another tone to begin. Since the NIST tones alternate between 500 Hz and 600 Hz, you should take this opportunity to switch between C5 and D5.

If the phase display appears to have stopped completely, then turn off Locking mode. This is done by pressing the **ESC**. If you have time, make one final check of your Offset adjustment after turning off the locking mode. If the phase display is still stopped, then you are done listening to the NIST tone and you can hang up the phone and proceed with **Completing the Calibration**.

Completing the Calibration

At this point you should have a temporary offset showing in the Current Settings box. This is the offset that caused the phase display to come to a stop when TuneLab was listening to NIST. You should also have a frequency showing in the current settings box. If you were locked onto one of the NIST tones, this frequency will be very close to either 500 Hz or 600 Hz, but it will not be exactly 500 Hz or 600 Hz unless the Offset that stopped the phase display just happened to be zero. The reason for this difference is that TuneLab has not been calibrated yet; so what it thinks is 500 Hz is not necessarily exactly 500 Hz. Do not change notes or anything else but proceed directly to finishing the calibration.

Select **Calibrate to External Reference** under the File menu. A box will appear with a field labeled “actual frequency”. The actual frequency field will already be filled in with a suggested actual frequency. If this is a NIST calibration, then TuneLab will fill in this box with 500.00 or 600.00 depending on which note was last selected. If the selected note is A4, then TuneLab will suggest exactly 440.00. Otherwise TuneLab will suggest the frequency that appeared in the current settings box, rounded to the nearest 1 Hz. This may be exactly what you need if the calibration error was small. If not, you may need to enter the correct frequency. If the calibration tone came from NIST, then the correct actual frequency should be 500.000 or 600.000, depending on which tone TuneLab was listening to last. Make sure that this exact frequency is entered and then click on OK. The calibration is now done. At this point TuneLab will automatically zero out any offset that you may have had prior to the calibration, because it is no longer needed, now that the new calibration is in effect.

NIST Calibration Checklist

- (1) NIST tuning file is loaded.
- (2) C5 is selected with 500 Hz showing.
- (3) Spectrum display zoom set to +/- 260 cents (so you can see both C5 and D5 at once).
- (4) Telephone sound can be heard by the microphone.
- (5) NIST schedule shows tones are available for the next few minutes.
- (6) Place the call to NIST.

Before calling NIST, make sure you can situate the telephone so that TuneLab can hear the tones. You can use the dialtone just to verify that it will work. Try to situate the telephone receiver directly over the microphone in your computer so that you are not holding it in your hands, because movement of the receiver will create noise that could interfere with the sounds TuneLab is trying to hear. When the call is answered, listen for a tone. Remember that the last 15 seconds of every minute has no tone, so you may have to wait up to 15 seconds. When a tone is heard, determine if it is 500 Hz or 600 Hz by selecting C5 or D5 until you see an indication in the phase display or the spectrum display. As soon as you find out which tone is being heard, use the Locking mode or manually adjust the offset in order to make the phase display stop. Remember that NIST will disconnect you after three minutes, so plan your usage accordingly. Finish the calibration as described above.

Verifying Calibration

After a calibration is complete, you may wonder if it completed properly. You can check this in several ways. From the **Help** menu, select **About**. A box will appear that shows, among other things, the actual sample rate. This is the actual end product of doing a calibration. The actual sample rate is stored in your computer to be used every time you start up TuneLab. If you are curious as to how far off TuneLab would have been without calibration, compare the actual sample rate shown in the About box with the nominal sample, which is 22,050. Now that you have done a calibration, it will not matter that the actual sample rate is different from the nominal rate because TuneLab knows about the difference, and is taking it into account in all its calculations. Another way to check calibration is to go back to NIST or some other trusted source of known pitch. Select the note and offset that makes the phase display stand still. If TuneLab is properly calibrated, the frequency display in the current settings box should be absolutely accurate and it should agree with the frequency of the trusted source.

Special Functions

Split Scale Mode (Spinets)

Most spinets (and some small grands, like the Yamaha GH-1) are difficult to tune because they have a large jump in their inharmonicity - usually at the point where the scale makes the transition between wound strings and plain strings. TuneLab has a special facility just for such pianos. This facility is called the "Split Scale".

If you want to use the Split Scale, then do this:

1. Take inharmonicity measurements of the two consecutive notes at the transition. (If the inharmonicity constants from these two measurements are not significantly different from each other, then discard one of the readings and do not use Split Scale mode.)
2. Measure three other notes below the transition.
3. Measure three other notes above the transition.

This pattern of inharmonicity measurements tells TuneLab to use the Split Scale tuning curve, and it also tells TuneLab exactly where the transition is.

An alternative way to start a Split Scale tuning file is from the New menu. Select "New Split Scale Tuning File". TuneLab will then ask you for the location of the break where you expect the inharmonicity to jump (typically the break between wound strings and bare wire strings). Once TuneLab knows this, it will figure out which notes you should measure and sequence through those measurements automatically.

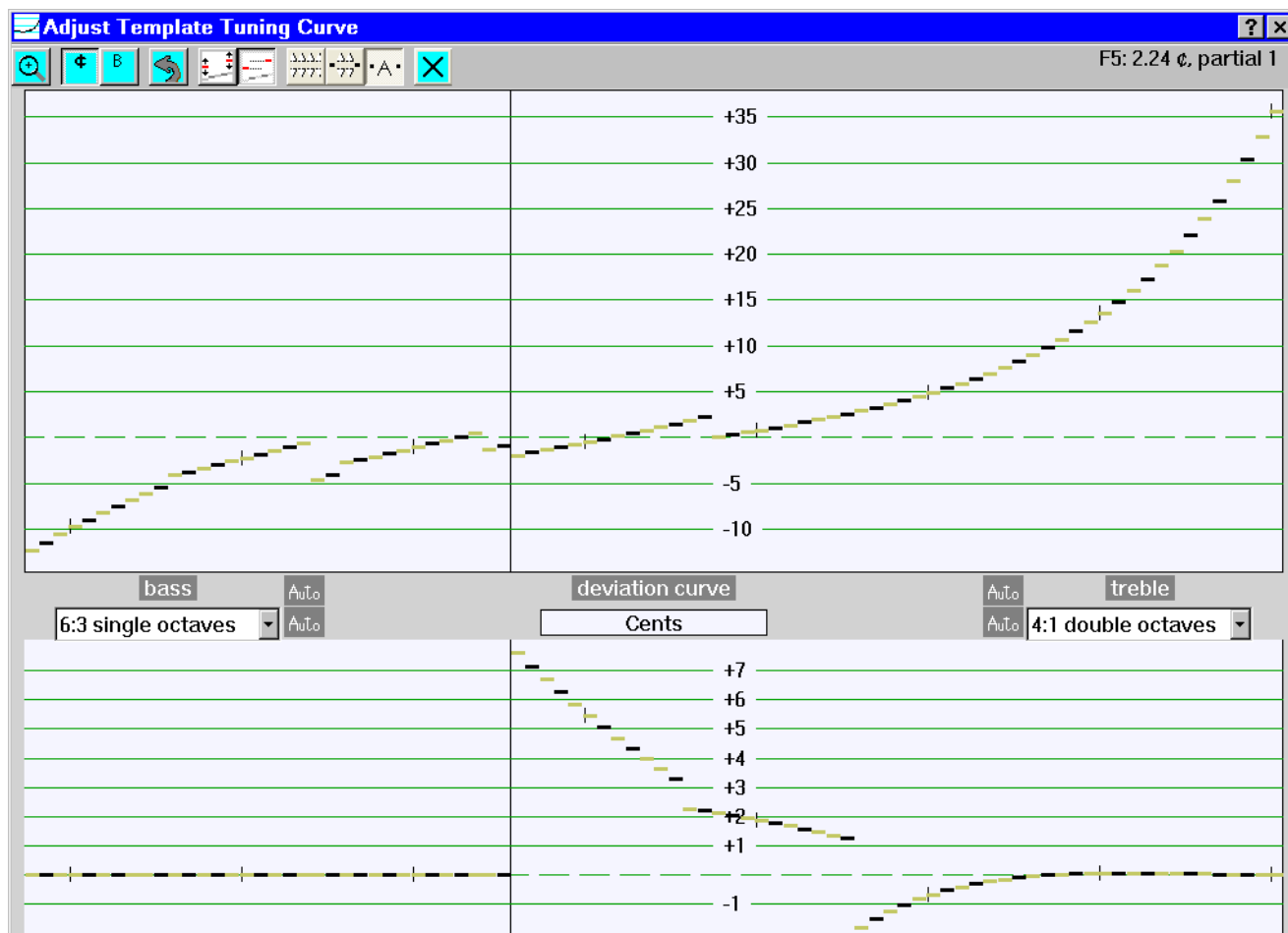
After you have measured inharmonicity as described above, you can invoke the tuning curve adjuster. The tuning curve adjuster shows when TuneLab is in Split Scale mode by placing a vertical line on the tuning curve and the deviation curve, as shown in the picture below. This vertical line shows the location of the break between the two parts of the split scale. If you do not see this vertical line in the tuning curve adjuster, then TuneLab is not in Split Scale mode. If you expected to see Split Scale mode, then review your list of inharmonicity readings. You will probably find that you have either:

1. less than four total inharmonicity readings below the break, or
2. less than four total inharmonicity readings above the break, or
3. more than one pair of consecutive inharmonicity readings.

If any of these conditions are true, then TuneLab will not go into Split Scale mode. For example, if you are tuning a Baldwin Acrosonic spinet, which has a break at F#3/G3, then you could invoke Split Scale mode by measuring inharmonicity at:

B0 G1 E2 F#3 G3 C4 A4 G5

When TuneLab is in Split Scale mode, the tuning curve adjuster buttons have a direct effect on the portion of the tuning curve above the transition. We recommend that you select 4:1 double octaves in the treble side of the tuning curve adjuster, and 6:3 single octaves in the bass side.



In Split Scale mode, the usual continuous model for the inharmonicity of the whole piano is broken up into two separate models - one for the portion of the scale below the transition and one for the portion above the transition. When you adjust the tuning curve, you will be directly adjusting only the portion of the tuning curve above the transition. The portion of the tuning curve below the transition will be automatically adjusted to give perfect 6:3 single octaves, if 6:3 octaves are what you selected for the bass. If you selected something else for the bass, then TuneLab will adjust the bass for 6:3 single octaves at the top of the bass and whatever you selected at the bottom of the bass. TuneLab will blend smoothly between these two intervals as you move down the scale in the bass. If you select 6:3 single octaves for the bass, then the deviation curve will show

exactly zero cents for the entire left half of the curve. When adjusting the tuning curve in Split Scale mode, we recommend the fully automatic method of adjustment as shown in the previous picture. The image shown above is what a good tuning curve and deviation curve might look like in Split Scale mode for a Baldwin Acrosonic Spinnet. Note the vertical line which indicates Split Scale mode.

The large deviations in the middle of the deviation graph are to be expected. Pianos that need Split Scale mode tend to have high inharmonicity just above the break. Although 4:1 double octaves in this region may be quite wide, 4:2 single octaves will be just about right. You can check the condition of 4:2 single octaves by temporarily switching to 4:2 in the treble. Make sure you switch back to 4:1 double octaves before making any further adjustments. After you have adjusted the tuning curve so that the deviation curve looks like the one above, focusing mostly on the far right end of the curve and how it sticks close to zero, then exit from the tuning curve adjuster and tune the piano as usual.

Tuning Exam Mode

From the Modes menu you can enter or leave Tuning Exam Mode. When this mode is active, the status box on the right side of the current note display is used to display the total offset, rounded to the nearest 0.1 cents, in keeping with the requirements of the PTG Tuning Exam. This display may be used to gather tuning offsets manually. Also, Tuning Exam Mode forces the use of the proper partials, as specified by the PTG Tuning Exam. In addition, there is a grading facility for comparing an examinee's tuning with a master tuning. See the separate document on using TuneLab in the Tuning Exam for details.

Making Temperament Files

Historical temperaments were described in Chapter 1. They are opened and attached to the current tuning using the "HT" icon in the TuneLab Pro toolbar. If you want to use a temperament that was not provided with TuneLab, you can create your own new temperament files from the **File** menu. All you need to know is the 12 offsets that define the temperament. After you enter the 12 offsets, you will be prompted to enter a file name for the new or modified temperament. When you make a new temperament file, you can then select it into any tuning curve just like the original temperament files.

Measuring Voicing

As a by-product of measuring inharmonicity, TuneLab creates a picture of the relative amplitudes of the various partials that were measured. All the partial amplitudes are rated in proportion to the strongest partial, which is rated at 100. The voicing display is part of the inharmonicity result display shown in Chapter 2. In that display you will see two sets of horizontal bar graphs - one white and the other black. The white bars show the amplitudes for the current measurement. The black bars show the amplitudes for a previously-saved measurement (using the "Save" pushbutton). In the case of the picture in Chapter 2, the previous measurement was made with a forté blow, and the current measurement was made with a much softer blow. This resulted in different relative amplitudes, especially for the second partial. Keep in mind the limitations in the use of this voicing measurement. The exact pattern of amplitudes depends greatly on the quality and the placement of the microphone, and on the strength of the hammer blow.

Measuring Sustain Time

Another by-product of an inharmonicity measurement is the sustain time, which is described as the length of time that a note sounds before fading so much that it cannot be heard. Although this definition is imprecise and subjective, piano rebuilders often need some measure of sustain time to evaluate the quality of the bridge and soundboard. The calculated sustain time is shown along with the results of the inharmonicity measurement. To measure sustain time, follow the normal instructions for measuring inharmonicity. However, there are several precautions regarding measuring sustain time.

One precaution is to turn off automatic gain control on the microphone, if your laptop soundcard offers such an option. Normally, automatic gain control would be a good thing because it brings up the level of the sound as the note decays, thus giving TuneLab more signal to work with. But automatic gain control will make the notes appear to sustain much longer than they really do, so the calculation of sustain time will be invalid. If you do change automatic gain control settings, you will have to switch temporarily to sound generating mode and back to listening mode for the change to take effect.

Another precaution is to be aware of the sound level as you strike the note. If the level reaches 100% for too much of the phase of the inharmonicity measurement, then no sustain time will be reported. You can preview the sound level by looking at the mic level indicator on the main screen. Learn how hard you must strike the note to achieve an initial 100% level, or thereabouts. A brief period of 100% level is OK as long as the level drops below 100% shortly thereafter.

Finally, make sure that the correct note is selected when you measure sustain time. Although the sustain calculation is not pitch-sensitive, the total sampling time does depend on which note is selected. TuneLab assumes a shorter sustain for higher notes, as you can see by noting the differences in the inharmonicity sampling times.

Auto Partial Selection

As stated in Chapter 1, the selection of which partial is used for each note can be modified by editing the table of partials as a whole, or by making individual on-the-fly changes. Sometimes individual bass strings are found to be weak in the pre-selected partial, making it difficult to tune them. You could manually try different partials, or you can let TuneLab change to a different partial by enabling the option for automatic partial selection. This option can be found under Edit Options. You specify a note below which automatic partial selection may occur, and how high a partial you will allow to be selected automatically. The default is to disable automatic partial selection completely. If you select a higher limiting note in your Options, then the lower notes will have automatic partial selection enabled.

When automatic partial selection is enabled for a note, then the partial selection may change during the first few seconds after you switch to that note. TuneLab will not change partials unless it finds a qualified partial that is at least twice as strong as the currently selected partial. TuneLab will only change partials once for each note switch. If an automatic partial change does occur, that change is treated exactly the same as if you had made the change on the fly manually. In particular, if the Persistent Partial option is enabled, the change is immediately incorporated into the current tuning file.

Menu Items and Options

Here is an item-by-item list of the menus used in TuneLab Pro.

File

New

New Tuning File - clears out any existing tuning file data and loads from **DEFAULT**.

Split Scale Tuning File - asks for the break, then starts new tuning file.

Unequal Temperament File

...by manually entering offsets If you know the 12 offsets that define an new unequal temperament, you can enter them here and make your own temperament file

...from Current Custom Stretch values - If you have a piano that has been tuned aurally in an unequal temperament and you would like to make a file that duplicates that temperament, then match at least one octave from that tuning using Custom Stretch values and then choose this menu item to use those Custom Stretch values to make an unequal temperament file.

Open Tuning File - lets you choose an existing tuning file to load.

Save Tuning File - saves the current tuning data into the current tuning file name.

Save Tuning File As... - saves the current tuning data and lets you choose a new file name.

Read Temperament File - lets you choose an existing unequal temperament file. (or press **F5**)

Rotate Temperament Starting Note - lets you transpose a temperament so that it is based on some other note besides C.

Cancel Temperament - returns the current tuning to equal temperament.

Calibration

Calibrate to External Reference - Choose this item **after** you have matched TuneLab to an external frequency source of pitch, such as NIST tones.

Calibrate Sound Gen from Listen Mode - Choose this item only if you need precise sound generation capability and have already done a basic calibration of TuneLab in the listening mode. See the help files to determine if this operation is necessary.

Save Overpull Measurements - Use this function after you are done tuning a piano in over-pull mode if you want a record of all the pre-tuned pitches for off-line study.

Exit - Exit from TuneLab. TuneLab will prompt you if you need to save a tuning file first.

Edit

Edit Inharmonicity Constants - Review and possibly edit the inharmonicity constants that resulted from inharmonicity measurements. (or press **Insert**) (Not generally needed)

Edit Template Tuning Curve - Switches the screen to the tuning curve adjuster. You can also switch to the tuning curve adjuster by pressing the **T** key on the keyboard.

Edit Partials - allows you to review and possibly change the table of partials currently in use. This table will be saved with the current tuning if you save the tuning file. (or press **P**)

Change Partial Lower - overrides the tuning file and changes to a lower partial. (or press **F3**)

Change Partial Higher - overrides the tuning file and changes to a higher partial. (or press **F4**)

Enter Current Settings - Allows you to enter Offers, Custom Stretch, Over-pull Percentage, and Basic Offset numerically. (or press **F6**).

Transfer Offset to Custom Stretch - If you have adjusted the offset for the current note and would like to make that offset a permanent feature of the tuning for the current note only, then use this menu item. (or press **F9**)

Transfer Offset to Basic Offset - If you have adjusted the offset and would like to make that offset apply to all the notes of the current tuning (as in tuning to A-442 instead of A-440) then use this menu item. Note that the basic offset is not saved in the tuning file. (or press **Shift-F9**)

Use RPT Exam De-tuning Offsets - If you need to prepare a piano for the RPT exam, use this function to enable the special offsets defined for this purpose. After preparing the piano you can use this same menu item to disable the special offsets.

Record A4 Fundamental for RPT Exam - If you have adjusted the offset to match the examinee's tuning of A4 with the partial set to fundamental, use this function to record that offset for later inclusion on the report that can be generated when grading the RPT tuning exam.

Zero All Custom Stretch Values - Use this function to remove all Custom Stretch values from the current tuning. This will not affect the template tuning curve or any historical temperament.

Edit Options - allows the setting of various options, listed later

View

Zoom Spectrum Display

Wide View - shows many partials at once. (or press “-“)

+/- 260 cents - shows 260 cents around the current note and partial. (or press “+” or “-“)

+/- 130 cents - shows 130 cents around the current note and partial. (or press “+” or “-“)

+/- 50 cents - shows 50 cents around the current note and partial. (or press “+”)

Exam Scoring - If you have matched an examinee's tuning by transferring all his/her offsets to Custom Stretch values then use this function to compare the resulting tuning with a previously saved master tuning which was also recorded using the Custom Stretch values.

Comments for this tuning - Lets you save comments attached to the current tuning file.

Modes

Generate Sound Output - switches to making tones instead of listening to them. (or press **S**)

Listen to Sound Input - switches back to listening instead of generating tones. (or press **S**)

Note Switching

Manual only - change notes manually (Shift down arrow).

Auto up - enables auto note switching to higher notes (Shift right arrow).

Auto down - enables auto note switching to lower notes (Shift left arrow).

Auto both directions - enables auto switching in either direct (Shift left and right arrows).

Timed up - enables timed note switching to next higher note (Alt right arrow).

Timed down - enables timed note switch to next lower note (Alt left arrow).

- Auto Measure** - enables auto sequencing through defined notes to measure for a new tuning
- Locking Mode** - enables the mode where TuneLab automatically adjusts the offset to match the tone that it hears. See the chapter on “All About Offsets” for more information. (or press “.”)
- Tuning Exam Mode** - selects correct partials for RPT tuning exam and displays offset rounded to the nearest 0.1 cents for recording master tunings and examinees’ tunings.

Help

- Help Topics** - invokes the complete help file for reference.
- Tutorial** - invokes a special help file that leads you through a step-by-step tutorial.
- About this version** - gives information about this version of the program.
- Enter License Information** - lets you convert the free trial version to the paid version.

Options (in Edit Options box)

- Use wide traces in spectrum graph** - makes traces three pixels wide instead of one pixel.
- Make partial changes persistent** - remembers in the tuning file any changes made to the selected partial using the F3/F4 keys in TuneLab Pro. If this option is not checked, then all such changes are temporary, and the partial selections in the tuning file stay as they are.
- Auto Partial Selection** - specifies which notes, if any, should use automatic partial selection. This option is for the lowest bass notes. See Chapter 6 for details. The default is for no auto partial selection. The highest partial that may be used can also be specified.
- Timed note switching time** - sets the time in seconds at which TuneLab will switch to the next note if timed note switching is enabled.
- Normalize Historical Temperaments** - allows the selection of three types of normalization: none (as is), normalize so that A=0, and normalize so that the average offset=0. The normalization shifts all 12 offsets for tuning, but does not change the original offsets in the tuning file or the temperament file.
- Measure Sequence** - switches to the screen where you specify which notes to measure for inharmonicity when creating a new tuning file.

Phase Display Options

- Speed Factor** - scales the speed of the phase display for all notes.
- Switch to Cents at...** - specifies the note at which the speed of the phase display switches to cents. Below this note, the speed of the phase display is based on beats. One beat of pitch error means one complete cycle of the phase display (if Speed Factor is set to 1). Above the specified note, the phase display speed represents the pitch error in cents. The higher you put this changeover point, the faster the phase display will be for the higher notes.