Delta Spectrum Research
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SVP Music Theory Stack

Card 1 of 38 card id 4053

Card 2 of 38 card id 6791

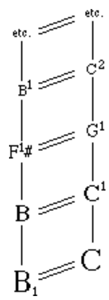
Beat Frequencies Dissonance

Dissonance or discord arises from beat frequencies generated from two or more tones.

These may occur in any of the following types:

1) Beat Dissonance Between Fundamentals;
2) Between one Fundamental and partial of the other;
3) Between Overtones;
4) From the occurrence of Differentials;
5) From the occurrence of Summation Tones.

Beat Dissonance Between Fundamentals



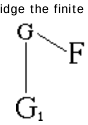
When beats arise between the fundamentals of two compound tones, the dissonance will in general be harsher than between two simple tones of the same pitch, for in the former case each pair of overtones may beat also. Supposing for example, the two fundamentals to be B1 and C, the diagram shows the dissonant overtones. The harshness of the beats between each pair of overtones in the diagram, must be estimated in the case of simple tones, for these overtones are simple tones; but in estimating the total harshness of the whole combination, it should be remembered that for ordinary qualities of tone, the intensity of the partials becomes less and less as we go farther from the Fundamentals (a fact roughly indicated in the diagram by the use of smaller type for the upper partials); and therefore the intensity of the beats will become less and less as we ascend. Nevertheless, these higher partials are always there even though we may not hear them or be able to measure them both going up and going down.

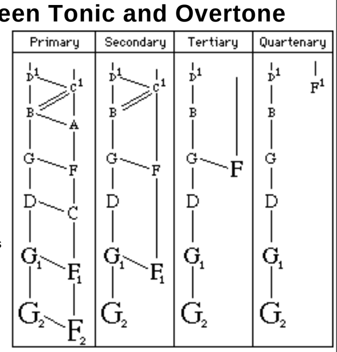
Beat Dissonance Between Tonic and Overtone

Beats arising from the Fundamental of one tone and an overtone of the other. As an example we may take the common dissonance between F and G1.

This interval, when sounded between simple tones, is quite free from harshness; the tones are far beyond beating distance, and no differential is near enough to prooduce beats. When, however, it is sounded between ordinary compoundtones, beats are generated by the fundamental F and the 2nd partial of G1.

The diagram only shows to the sixth partials. In reality the partials are generated in infinite numbers far beyond our ability to hear or measure them. This shows how Music may bridge the finite to the infinite.





Beat Dissonance Between Overtones

Partials of C	=	256,		512,	768,	1024,	1280
Partials of $G\#_1$	=	200,	400,	600,	800,	1000,	1200
Beats formed:		156		112	32	24	80

Partials of $G\#_1$	=		200,	400,		600,	800
Partials of C_1	=	128,	256,	384,	512,	640,	768
Beats formed:			56	16		40	32

To complicate matters even more, these beat tones will also become generators themselves and create secondary, tertiary, etc. orders of beats. This is taken to be the Jacob's Ladder of the Bible and also demonstrates "as above - so below" and that all things are connected.

Beats arising from the overtones of Compound Tones. In music it is considered a beat when the resultant numbers are small. The 156 and 112 of the first series is not considered a beat frequency as is the 56 in the lower series. However, these tones are generated and constitute a new tone resulting from the generator tones.

Only the first six partials are shown. The actual number of partials are infinite and consequently there are many more beats present even though they are not heard or measured.

Beat Frequencies Between Differentials

Simple Tones and Harmonics	200	400	600
	Difference Tones		
304	104	96	296
608	408	208	8

104	208	304	408	400	600
96	200	296	400	304	608
8	8	8	8	96	8

According to musical theory beats of 8, 96 and higher numbers are beyond the range of beats which are normally heard. But in hard numbers these secondary tones are present and should be accounted for even though they are not heard or measured.

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Beat Frequencies due to Summation Tones

360 **Compute**

Interval	Ratio	Rate : Rate	Calculate Summation	Summation Tone
Octave	2 : 1	720 : 360	360 + 720 = 1080 = 3	G
Fifth	3 : 2	1080 : 720	1080 + 720 = 1800 = 5	E'
Fourth	4 : 3	1440 : 1080	1440 + 1080 = 2520 = 7	A#'''
Major Third	5 : 4	1800 : 1440	1800 + 1440 = 3240 = 9	D^{iv}
Minor Third	6 : 5	2160 : 1800	2160 + 1800 = 3960 = 11	F'''
Major Sixth	5 : 3	1800 : 1080	1800 + 1080 = 2880 = 8	C^{iv}
Minor Sixth	8 : 5	2880 : 1800	2880 + 1800 = 4680 = 13	$A\flat^{iv}$
Major Second	9 : 8	3240 : 2880	3240 + 2880 = 6120 = 17	B^{iv}
Diatonic Semitone	16: 15	5760 : 5400	5760 + 5400 = 11160 = 31	$A\sharp^{v}$

From the above table we can see that the fundamentals of the Octave generate the Summation Tone of C which coincides with the 3rd partial of the lower tone, so in the case of the Octave no new element is introduced however the Summation Tone is present.

All of the other intervals must be treated in like manner. The first beat is from the Fourth which comes near beating distance of the 2nd partial of C: 400 + 300 = 700; 2nd partial of C is 800; therefore 800 - 700 = 100.

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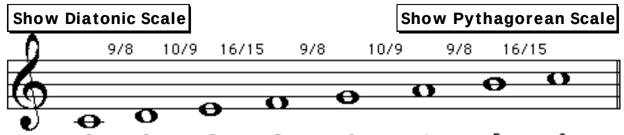
Building Scales

Show Diatonic Scale **Show Pythagorean Scale**



C	D	E	F	G	A	B	C
256	288	324	341.3	384	432	486	512

Building a scale: It should be noticed that a scale can be constructed on any vibration number as a foundation or fundamental. Type any number into the field below C and click on the Diatonic Scale button. Using 288 will create a scale of whole numbers. Other numbers may also create scales of whole numbers while yet other numbers may create decimal fractions of an integer. The distance or interval is given by the fractional ratios listed across the top of the measure, i.e., the interval of D from C is 9/8 or C divided by 8 and then multiplied by 9 = D.

There are any number oftypes of scales. The above ratios are for the Diatonic Scale. With the same fundamental (C) there are different intervasl between the Diatonic and Pythagorean Scales as can be seen by clicking either button.

Calculating Compound Difference Tones

To determine what differentials of the second and third orders can be present in an interval, we proceed as follows: For example, let the two generators be a Major Third or 5:4.
The relative vibration rate of the differential of the first order is: 5 - 4 = 1. Subtracting this from the generators 5 and 4 we obtain the relative vibration rates of the differentials of the second order: i.e., 5 -1 = 4 and 4 - 1 = 3, this latter only being a new tone. Again, subtracting this 3 from the higher generator, we get another new tone 5 - 3 = 2, a differential of the third order.

Major Third 5 : 4

generators E" = 5 = 640
C" = 4 = 512

Differential of 1st Order C = 1 = 128 (= 5 - 4)
Differential of 2nd Order G' = 3 = 384 (= 4 - 1)
Differential of 3rd Order C' = 2 = 256 (= 5 - 3)

Clefs

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Clefs, Treble and Bass

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Combination Tones

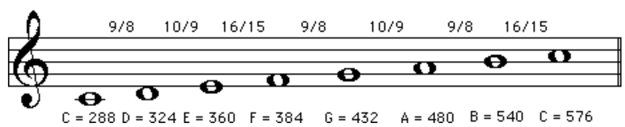
A Combination Tone is a third sound, which may be heard or measured, when two tones of different pitch are simultaneously sounded, and which are not heard, when either of these two tones is sounded alone.
The two tones which give rise to a Combination Tone are termed its generators.
There are two kinds of Combination Tones:
Differential Tone : the vibration number which is the difference of the vibration numbers of its generators.
Summation Tone : the vibration number which is the sum of these generator vibration numbers.

Differential Tones may be of various orders:
A Differential of the 1st order is that tone produced by two independent tones or generators.
A Differential of the 2nd order is that tone produced by the Differential of the 1st order, and either of the generators.
A Differential of the 3rd order is that tone produced by the Diffferential of the 2nd order, and either of the previous tones being either the Differential of the 1st or 2nd orders and/or one of the generators.
A Differential of the 4th order is that tone produced by the Differential of the 3rd order and either of the previous tones; and so on.

Interval	Difference			
	1st Order	2nd Order	3rd Order	4th Order
Fourth 4 : 3 G : C 512 : 384	1 = 128 = C			
Major 3rd 5 : 4 E : C 640 : 512	1 = 128 = C	3 = 384 = G	2 = 256 = C'	
Minor 3rd 6 : 5 G : E 768 : 640	1 = 128 = C	4 = 512 = C''	2 = 256 = C' 3 = 384 = G	
Major 6th 5 : 3 E : C 640 : 512	2 = 256 = C'	1 = 128 = C	4 = 512 = C''	
Minor 6th 8 : 5 C : E 1024 : 640	3 = 384 = G	2 = 256 = C'	6 = 768 = G' 1 = 128 = C	7 = 896 = B' 4 = 512 = C''

Compound Difference Tones

Diatonic Scale



DIATONIC: 1) One of the three genera of music among the Greeks, the other two being the chromatic and enharmonic. 2) The modern major and minor scales. 3) Chords, intervals, and melodic progressions, etc., belonging to one key-scale. A diatonic chord is one having no note chromatically altered. A diatonic interval is one formed by two notes of a diatonic scale unaltered by accidentals.

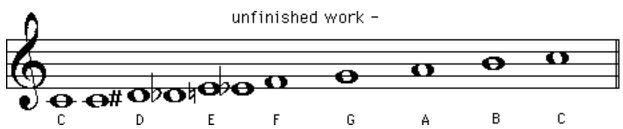
Difference Tones

Interval	Ratio	Rate : Rate	Calculate Difference	Difference Tone
Octave	2 : 1	512 : 256	256 - 128 = 128 = 1	C
Fifth	3 : 2	384 : 256	384 - 256 = 128 = 1	C
Fourth	4 : 3	512 : 384	512 - 384 = 128 = 1	C
Major Third	5 : 4	640 : 512	640 - 512 = 128 = 1	C
Minor Third	6 : 5	768 : 640	768 - 640 = 128 = 1	C
Major Sixth	5 : 3	640 : 384	640 - 384 = 256 = 2	C'
Minor Sixth	8 : 5	1024 : 640	1024 - 640 = 384 = 3	E
Major Second	9 : 8	1152 : 1024	1152 -1024 = 128 = 1	C
Diatonic Semitone	16 : 15	2048 : 1920	2048 -1920 = 128 = 1	C

The vibration number of a differential tone is the difference between the vibration numbers of its generating vibration numbers. It is easy therefore to calculate what differential any two given generators will produce. Further, if the two generators form any definite musical interval the differential tone may be easily ascertained, though their vibration numbers be unknown.

Enharmonic Scale

unfinished work -



ENHARMONIC: 1) One of the three genera of Greek music, the other two being the Diatonic and Chromatic. 2) Having intervals of less than a semitone, e.g., an enharmonic organ or harmonium is an instrument having more than twelve divisions in the octave, and capable, therefore, or producing two distinct sounds where, on the ordinary instrument, one only exists, as, for instance a scale having both G# and Aflat. An enharmonic scale is one containing intervals less than a semitone.

Fibonacci Numbers

Fibonacci is Music **Create Numbers**

Fibonnacci was a monk who lived about 1100 AD. When studying the reproduction rates of rabbits he came upon a method of calculating natural progressive rates. You can see how this works by typing any two sequential prime numbers into the first two fields to the right then click on the Create Numbers button above.

The process used is simple: add the second number to the first number to create the third number until infinity is reached (never). See SVP Compendium of Terms for greater detail.

3
4
7
11
18
29
47
76

Fibonacci is Music

1 : 1 : 2 : 3 : 5 : 8 : 13 : 21...

1 : 1	Unison
3 : 2	Perfect 5th
8 : 5	Minor 6th
21 : 13	Minor 6th
∞ : ∞	Harmonic 6th
34 : 21	Major Sixths
13 : 8	Major Sixths
5 : 3	Major 6th
2 : 1	Octave

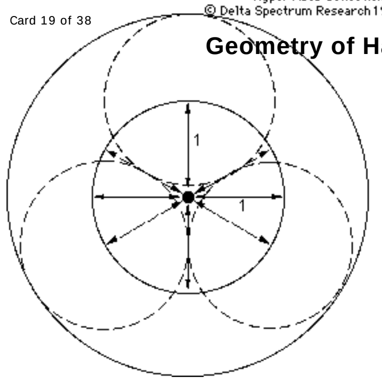
Fibonacci Numbers

The Fibonnaci series is the base of music. Here we have the series going up which breaks into a smooth series of even musical intervals.

When the numbers are going in reverse order we can see the spontaneous generation of odd or enharmonic musical intervals.

The two series will progress to infinity always attempting to form an Harmonic 6th which does not exist in music or nature because the Harmonic 6th signifies perfect unity or harmony or equation of forces. Should this happen the forces then become latent and non-perceptable.

Geometry of Harmony



1:1:1 ratio

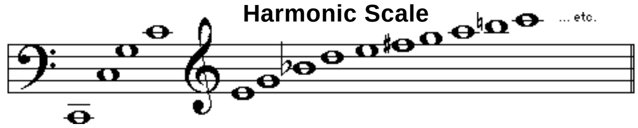
Geometric harmony is represented here by circles long regarded as a symbol of perfection.

All the radii bear a ratio of 1:1 to each other thus showing there are no partial differences between them.

Thus they are here proven to be in a state of harmony.

Geometric Proportion

Harmonic Scale



A harmonic scale is formed by taking a series of notes produced by vibrations whose numbers in a given time are respectively as 1, 2, 3, 4, etc. If we take as fundamental tone the open C string of the violoncello, the series of tones which with it form a harmonic scale will be as pictured above.

HARMONIC SCALE: The scale formed by a series of natural harmonics. It should be noted that our conventional music scale is a melodic modification of a naturally occurring harmonic scale or series of naturally occurring tones.

As the character of a sound depends upon that of the vibrations by which it is caused, it is important to know of what kind the latter must be in order that they may give the sensation of a perfectly simple tone, i.e., one which the ear cannot resolve into any others. Such a vibration is perhaps best realised by comparison with that of the pendulum of a clock when it is swinging only a little to and fro. Under these circumstances it is performing what are called harmonic vibrations, and when the air particles in the neighborhood of the ear are caused by any means to vibrate according to the same law as that which the pendulum follows, and also with sufficient rapidity, a perfect simple tone is the result. Such a tone is, however, rarely heard except when produced by means specially contrived for the purpose. If a note on the pianoforte is struck, the impact of the hammer on the string throws it into a state of vibration, which, though periodic, is not really harmonic; consequently we do not hear a perfectly simple tone, but one which is in reality a mixture of several higher simple tones with that one which corresponds to the actual length of the string. The former are, however, generally faint, and become associated by habit with the latter, appearing to form with it a single note of determinate pitch. These higher tones are harmonics of the string, and are produced by vibrations whose numbers per second are respectively twice, three times, four times, etc., as great as those of the fundamental tone of the string.

Intervals

Major 6th

An interval in music is distance (between the notes) expressed in terms of difference in pitch. Sound the two tones to the right. The ear immediately detects that one tone is higher than the other. The eye detects the interval which is represented graphically by two signs (notes), one of which is higher on the staff than the other. This audible and visible highness is, in music, distance or interval. This distance can be measured. To measure an interval we must have a definite and unchangeable unit of measure.

In expressing intervals by name several technical terms are employed. For example: this interval is a Major Sixth because there are six steps (inclusive) between the two tones. We infer from the word Major that there are other kinds of sixths, and from the word sixth we infer that in naming intervals, something is counted, something which in this example contains six distinct units.

Major Interval

Major 6th

To determine the number name of an interval we must be able to count from one to nine, and to say the first seven letters of the alphabet. To determine the specific name of an interval we must know the Major Scale of the lower tone of the given interval. This will inform us if the upper tone of the given intereval be in the Major Scale of the lower tone, or if it be above the Major Scale tone, or if it be below it.

RULE: An interval is Major when the upper tone is found in the Major Scale of the lower tone.

D (in the diagram) is the sixth degree or step or tone in the Major Scale of F. Numerically F to D is a Sixth. Hence the interval is accurately described when we say it is a Major Sixth. Major Intervals are the 2nd, 3rd, 6th, 7th and 9th.

Minor Interval

The Minor Interval is a Major Interval where the upper tone is not found in the Major Scale of the lower and the interval is slightly less distance than a Major Interval.

Just as we have the Major 2nd, 3rd, 6th, 7th and 9th so we also have the Minor 2nd, 3rd, 6th, 7th and 9th.

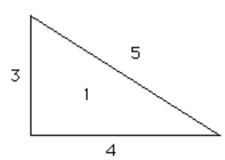
The Major interval above and right is six steps between the C and A. The Minor Interval to the lower right is marked slightly less or smaller than six steps with the flat sign indicating the A is flattened or slightly lowered in pitch from its natural pitch when found in the Major Scale of C.

Major Sixth

Minor Sixth

Intervals of Triangle

Go to next card to see more on Quantum Arithmetic and Musical Intervals.



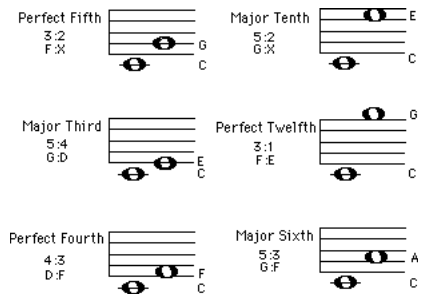
Music Intervals of the triangle

Unison	1:1
Octave	2:1
Perfect Fifth	3:2
Major Third	5:4
Perfect Fourth	4:3
Major Tenth	5:2
Perfect Twelfth	3:1
Major Sixth	5:3
Double Octave	4:1

The ratios above are taken directly from a plot of a right triangle created using the rules of QA. It is interesting to note that of the nine ratios six are Perfect Intervals (1, 2, and 3 par numbers) the remaining three are all Major Intervals (5 par numbers). This demonstrates that the triangle is indeed a unit of strength.

Intervals

The various symbols used in Quantum Arithmetic are interchangeable with music notes and form Music Intervals when related one to another. The Music Intervals given to the right are derived from the primary symbols of QA which are found to be involved with a right triangle. (Below the interval name are given the numeric ratio of that interval and below that are given the QA symbol ratios.)



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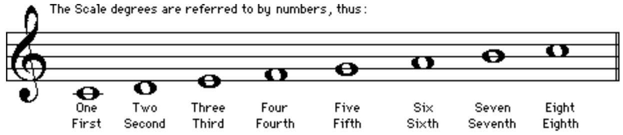
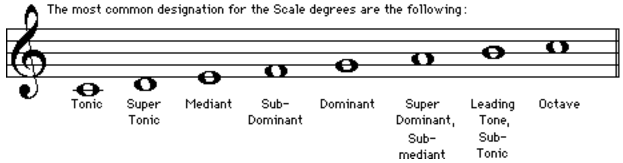
Notes & Scales

The Scale degrees are referred to by numbers, thus:

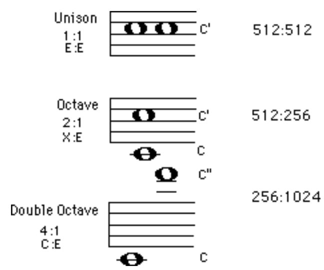


The most common designation for the Scale degrees are the following:



Octaves

The two music intervals drawn to the right are for Unison and the Octave which is a doubling or halving of the two tones ratioed to create Unison. In the case given it is a halving of one of the unit tones. In this example we have two tones of C and C each with 512 cycles per second. The Octave is one C with 512 cps and one C with 256 cycles per second. The Double Octave is 4:1 ratio or twice the Octave ratio.



Perfect Interval

The Perfect Interval is a Major Interval where the lower tone is found in the Major Scale of the upper tone as well as the upper tone is found in the Major Scale of the lower tone.

The Major 6th to the right is Major as D is part of the Major Scale of F but F is not part of the Major Scale of D. Therefore it is not a Perfect Interval.

The Perfect 4th to the lower right is Perfect because F is found in the Major Scale of C and C is found in the Major Scale of F.

Perfect Intervals may be a 1st, 4th, 5th and 8th.

Major 6th

Perfect 4th

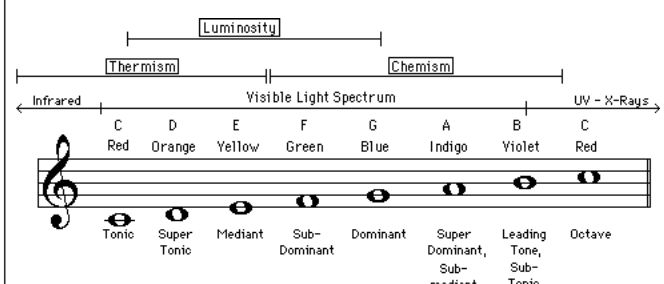
Power of Beat Harmonics

Harmonic	Note		Relative Intensity	Frequency
First harmonic	C'	=	29	257
Second harmonic	C''	=	7	514
Third harmonic	G''	=	20	771
Fourth harmonic	C'''	=	1	1028
Fifth harmonic	E'''	=	2	1284
Sixth harmonic	G'''	=	6	1542
Seventh harmonic	B'''	=	6	1928
Eighth harmonic	C^{iv}	=	8	2056
Ninth harmonic	D^{v}	=	16	2312
Tenth harmonic	E^{iv}	=	9	2568
Eleventh harmonic	$F\#^{iv}$	=	30	2827
Twelfth harmonic	G^{iv}	=	35	3084

It is of interest to notice that the eleventh and twelfth harmonics, of frequencies 2827 and 3084 respectively, are both stronger than the fundamental note of frequency 257, and as the ear is many times more sensitive to notes of the higher frequencies than to notes of the lower, the sound which the ear perceives must consist almost entirely of tones of these higher frequencies.

In other words, the eleventh and twelfth harmonics are composed almost entirely of beats of the lower frequencies. Thus the eleventh and twelfth harmonics are referred to as the "beat harmonics".

Light, Properties of



The colors given are of the hues or light and not of pigment.

Ratios - Quantizing to One

Music is based on numbers and ratios of those numbers related to another number. This relativity is designated by the use of ratios. For instance, Unison is expressed as 1:1 meaning 1 related to 1 is Unity or we may say they equate each other. The ratio for an Octave is expressed 1:2 or 2:1. The 2 is twice the value of 1 therefore an Octave is composed of two values one of which is twice the other: 2:1::1024:512. This expression is read: 2 is to 1 as 1024 is to 512. In other words the value of 512 is the same relative value as 1 to 2 when related to the value of 1024.

This process of relating 1 to 512 is called "quantizing to 1". Any quantity or frequency can be so quantized to 1. This is in conformity with the Law of One. Any other quantity or frequency can then be quantified on the ratios of music when counting from 1.

Thus if we assign 512 as the root which becomes 1; the Octave of 512 is then twice this amount or 1024 and we still preserve the ratio of an Octave as 1:2.

1 = Fundamental

Standard Intervals #1 - 1 of 3

Unison	1:1	1
Pythagorean Comma	81:80	1.013
Enharmonic Step	128:125	1.024
Lesser Chromatic Semitone	25:24	1.042
Diesis	25:24	1.042
Greater Chromatic Semitone	135:128	1.055
Minor Diatonic Semitone	17:16	1.062
Major Diatonic Semitone	16:15	1.067
Limma	16:15	1.067
Minor Second	27:25	1.08
Smaller Step or Minor Tone	10:9	1.111
Greater Step or Major Tone	9:8	1.125
Major Second	9:8	1.125
Augmented Second	75:64	1.219
Minor Third	6:5	1.2
Major Third	5:4	1.25
Diminished Fourth	32:25	1.28
Augmented Third	125:96	1.302
Perfect Fourth	4:3	1.333

Calculate

An interval is the distance between two notes. An interval is also the combination of these two tones. The quality of an interval is determined by its size and by the relationship of its position to the keynote or Fundamental.

There are five types of intervals: Major, Minor, Perfect, Diminished and Augmented.

A Major interval contracted by lowering the upper note or raising the lower note by one half step becomes Minor, and contracted another half step becomes Diminished.

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64 = Fundamental

Standard Intervals #2 - 2 of 3

Augmented Fourth	25:18	88.889
Tritone	45:32	90
Diminished Fifth	64:45	91.022
Diminished Fifth	36:25	65.829
Perfect Fifth	3:2	96
Augmented Fifth	25:16	100
Minor Sixth	8:5	102.4
Major Sixth	5:3	106.667
Augmented Sixth	125:72	111.111
Harmonic Seventh	7:4	112
Dominant or Minor Seventh	16:9	113.778
Minor Seventh	9:5	115.2
Tonic Seventh	9:5	115.2
Major Seventh	15:8	120
Diminished Octave	48:25	122.88
Augmented Seventh	125:64	125
Octave	2:1	128
Minor Ninth	32:15	136.533
Major Ninth	9:4	144

Calculate

A perfect interval contracted by a half step becomes diminished, and contracted by yet another half step becomes doubly diminished.

A perfect or major interval expanded by a half step becomes augmented.

Harmony is concerned with chords, and every chord is a combination of intervals sounded simulataneously.

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Standard Intervals #3 - 3 of 3

64 = Fundamental

Harmonic Minor Tenth	7:3	149.333
Minor Tenth	12:5	153.6
Major Tenth	5:2	160
Perfect Eleventh	8:3	170.667
Harmonic Eleventh	11:4	176
Augmented Eleventh	45:16	180
Perfect Twelfth	3:1	192
Augmented Twelfth	25:8	200
Minor Thirteenth	16:5	204.8
Harmonic Thirteenth	13:4	208
Major Thirteenth	10:3	213.333
Harmonic Fourteenth	7:2	224

Calculate

The frequencies of a note are not fixed except in context of an established scale. By entering any number in the Fundamental field above and to the left the computations (click Calculate button) determine what the other relative frequencies (intervals) are. Notes are relative pitches and not fixed frequencies. On the other hand, in a given scale, the intervals or the distances between the notes are fixed relative to each other. For more information see Ratios and Intervals cards.

Card 35 of 38 card id 13151

Summation Tones

Interval	Ratio	Rate : Rate	Calculate Summation	Summation Tone
Octave	2 : 1	512 : 256	256 + 128 = 384 = 3	G
Fifth	3 : 2	384 : 256	384 + 256 = 640 = 5	E'
Fourth	4 : 3	512 : 384	512 + 384 = 896 = 7	A#'''
Major Third	5 : 4	640 : 512	640 + 512 = 1152 = 9	D^{iv}
Minor Third	6 : 5	768 : 640	768 + 640 = 1408 = 11	F'''
Major Sixth	5 : 3	640 : 384	640 + 384 = 1024 = 8	C^{iv}
Minor Sixth	8 : 5	1024 : 640	1024 + 640 = 1664 = 13	$A\flat^{iv}$
Major Second	9 : 8	1152 : 1024	1152 + 1024 = 2176 = 17	B^{iv}
Diatonic Semitone	16 : 15	2048 : 1920	2048 + 1920 = 3968 = 31	$A\#^{v}$

Helmholtz worked out the theory, mathematically, and proved that two tones with given vibration numbers, may not only produce a third tone, having its vibration number equal to their difference (Difference Tone), but also another tone equal to their sum.

Tones will also sum with the Difference Tones present and their harmonics (overtones) and all other partials producing a plethora of vibration numbers.

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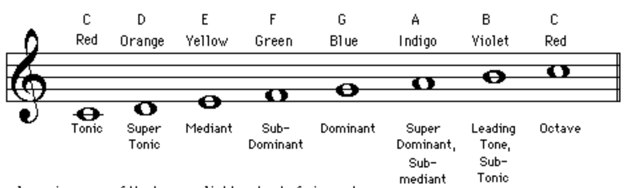
Tones of Colors

Red to Yellow	6 : 5	Minor Third
Yellow to Blue	5 : 4	Major Third
Red to Blue	3 : 2	Perfect Fifth

By using the wavelengths of various colors of light and ratioing them as one would musical tones they combine to form equivalent intervals as are found in music.



The colors given are of the hues or light and not of pigment.

Triads - Tri-tone Chords

The material of which music is made is tone, in recognizable, orderly chord groups. The simplest chord group is the Triad, or three tone chord. The Triad always consists of fundamental (root), third and fifth. A Triad may be constructed upon every degree of the scale, Major and Minor. Upon the Major Scale tones the Triads of the key, in C Major, are shown above. These seven Triads occur in exactly the same form in every Major Key. There are three different Triad groupings in the above:

Major Triad: Major 3rd and Perfect 5th on the 1st, 4th and 5th degrees.
Minor Triad: Minor 3rd and Perfect 5th on the 2nd, 3rd and 6th degrees.
Diminished Triad: Minor 3rd and Diminished 5th on the 7th degree.

Wave Form Components - aliquot parts

Diagram showing the component notes (aliquot parts) when merged or synthesized together combine to form the different waveforms pictured above the chart.