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Appendix C

GLOSSARY

-> - 'arrow' abbreviation for modulating to, e.g. Metric Six modulating to Metric Two, M6->M2.

absolute music - 'pure' music, music which does not rely on external elements or references for its logic or meaning. Usually instrumental.

accent - a rhythmic or dynamic (loudness) stress which picks out one note from among its neighbours.

accidentals - Three symbols which change the pitch of notes within a score. The *sharp* (#) raises the note by a semitone, the *flat* lowers it by a semitone and the *natural* neutralises a pre-existing sharp or flat – usually emanating from the key signature. Double sharps and flats act upon notes already sharpened or flattened to raise or lower them by a further semitone.

allegro - A music tempo marking meaning lively, brisk or rapid.

algorithm - A fixed rule or scheme applied to transform data/information. The word algorithm derives from the name of a great Persian mathematician, al-Kuwarizmi working in Bagdad in the ninth century.

amplitude - Maximum disturbance from equilibrium, the maximum height or depth of a wave peak or trough.

arithmetic series - A series in which each term is formed from the preceding term by adding a constant value. Arithmetic series are inverted harmonic series and vice versa, mirroring the inverse relationship between frequency and wavelength. In *Journey to the Heart of Music*, the abbreviation/prefix 'a' is occasionally used to distinguish between harmonics (h1, h2, h3, etc.) and 'arithmonics', e.g. a1, a2, a3, etc. Effectively 'h' values refer to frequency and 'a' values to wavelength. While the harmonic series h1-h6 produces the common major chord - C, C, G, C, E & G - its inversion, an arithmetic series a1 through a6 (descending 8ve, 5th, 4th, maj3rd and min3rd) produces the common minor chord: C, C, F, C, Aflat & F.

arpeggio - A chord played rapidly one note at a time in ascending or descending order.

atom - A basic unit of matter consisting of a central nucleus containing protons and neutrons surrounded by a cloud of electrons.

atonality - A style of musical composition designed specifically not to rely on a sense of key or tonal centre, sometimes termed pantonality - music in all keys simultaneously. The negation of tonality.

auditory pathway - The band of nerves and automatic processing units connecting the ears to the higher levels of aural cognition in the cerebral cortex. The nerves run, with many cross-connections between the left and right sides, from the cochlea in each inner ear, to the lateral olives (volume) and medial olives (transients) and on to the lateral lemniscii (direction), inferior colliculii (reflex actions) and geniculate bodies (sensory awareness); before entering the cortices.

- basilar membrane** - The resonant detector membrane at the center of the cochlea in the inner ear. The membrane possesses a graded stiffness which allows it to spread the resonance of the constituents of sound along its length. Very neatly, from the high frequencies at the entrance to the cochlea to the low frequencies at the far end, it separates and signals via nerve cells laterally attached, the components of sound stimuli.
- bar/barline** - The demarcation of the principal metrical period by a vertical line on the music staff/staves. See measure.
- beat** - The division of the measure into sub-units, the measure-note, normally the value of the denominator of the time-signature - i.e. 4/4 measure-note = 1/4, a quarternote.
- beats** - The interference pattern of two notes of close but not identical frequency.
- cadence** - A harmonic progression marking the end of a musical phrase. The most used and firmest cadence being the dominant to tonic chord progression V → I, - a full or perfect cadence. The ratios of the dominant to tonic notes are 3:4 ascending and 3:2 descending.
- cantus firmus** - A pre-existing melody used as the basis for a new composition. Originally, in the middle ages, a plain chant melody used as the basis for a polyphonic piece but later the term gained a more general application.
- cellular automata** - A scheme of data/information, arranged in the form of 'cells' which can be in a number of states (e.g. black, grey or white; X or !X -i.e. X or space character) and which move to new arrangements of states by the application of a fixed rule.
- chorale** - Hymns of the Lutheran church, many harmonised by J.S.Bach, used in the study of harmony. The music student's equivalent to the study of Newtonian mechanics in physics, perhaps?
- chord** - Two or more notes sounding simultaneously. A harmonic entity.
- chromatic (scale)** - Music based on or moving in semitone steps.
- clef** - An ornamented letter on the staff which indicates the pitch of one of the staff's lines and thereby fixing the pitch of all the other lines and spaces on that staff, i.e. G-clef/treble clef, F-clef/bass clef.
- cochlea** - A spiral shell-like detection unit in the inner ear containing the basilar membrane and nerve cells. Sound received at the ear drum is conveyed via three small bones (malleus, incus and stapes), in the air filled middle ear, to the entrance of the cochlea. The basilar membrane detects sound by sympathetically resonating with sound waves passing through the liquid filled cochlea. The movement of the basilar membrane is transmitted via three amplifier cells to an adjacent 'hair' cell which sends nerve pulses down the auditory pathway. The pulses are thus linked (though not in an entirely one-to-one manner) to the frequency period of the resonance detected. About 7500 hair cells line the edge of the basilar membrane in the cochlea.
- combination tones** - Aural sensations or 'ghost notes' generated within the mechanisms of the ear, which bear frequency relationships of subtraction or addition to the actual objective notes being heard. Interestingly, a major triad - C E G - will generate difference and summation tones which cover the range h1, h2, h3, C, E, G, h7, h8, h9, h10, h11, h12, h13, h14, h15, h16, h17 & h18. It is possible that combination tones play a role in the processing of aural information, particularly the lowest frequency difference tone, which provides a 'fundamental' period within which patterns of compound metrical form might be drawn, by the actual objective frequencies.
- comma** - A term for a small difference between two schemes of measurement or calculation, which beginning from the same point of departure, eventually again coincide (almost) at some further point. The amount of the 'almost' mismatch, is the size of the comma.

Didymic comma: the difference (22% of a semitone) between the frequency of the key of E derived as the fourth key in the cycle of fifths (1.5^4) and h5 of the harmonic series (1.25% overall). Thus both starting from the same h1 fundamental:

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KEY:Cmajor f=1-equal starting point->C h1(f=1)
KEY:Gmajor f=(1 × 1.5)= 1.5 C h2(f=2)
KEY:Dmajor f=(1.5 × 1.5)= 2.25 G h3(f=3)
KEY:Amajor f=(2.25 × 1.5)= 3.375 C h4(f=4)
KEY:Emajor f=3.375 × 1.5 = 5.0625 -> E h5(f=5) 1.25%
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Other commas: If the key cycle procedure of multiplying by 1.5 is continued, other unnamed commas are encountered before the Pythagorean comma.

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KEY:C#Major f=(1.5^7) = 17.085937->C# h17(f=17) 0.5%
KEY:A#major f=(1.5^10) = 57.665035->A# h56(f=56) 2.97%
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Pythagorean comma: the difference (24% of a semitone, 1.36% overall) between measuring out the twelve perfect fifths and seven octaves used to construct the relationships of the 12 notes and 12 key centres used in western tonal music. Equal temperament hides this small difference by distributing it (equally) among the each of the twelve semitones.

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KEY:Cmajor f=(1.5^12)= 129.74 -->C h128(f=128) 1.36%
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If the Didymic comma were to re-calibrate the pitch of the harmonic series of origin, by raising it by 1.25%, this would effectively reduce the Pythagorean comma to 0.11%, as over the whole cycle the total difference is 1.36%.

common time - A compound duple meter (4/4) indicating four quarternote beats per bar or measure, with two levels of stress, the stronger on the first beat followed by a weaker stress on the third.

compound meter - A complex or multi-layered meter involving the nesting of one (usually) simple meter within another. For example, two nested simple 2/4 meters produce a compound duple 4/4 meter or simple 3/8 nested within simple 2/4 produces a compound duple 6/8 meter.

consonance - A harmonious collection of notes, difficult to define as it depends largely on human judgement. However, the mathematician Leonard Euler has provided a firm measure in the Lowest Common Multiple of the frequency ratios of a chord's notes.

continuo - In full, basso continuo, the characteristic accompaniment of the baroque era consisting of harpsichord or plucked instrument and usually a melodic bass instrument -i.e. 'cello. See figured bass and monody.

cycle/spiral of fifths - The relationship arising from the construction of the twelve notes of the chromatic scale by fitting twelve intervals of a fifth into seven octaves, each note thus having the pitch/frequency relationship of 2:3 (the interval of a fifth) to the next ascending note. The sequence is C, G, D, A, E, B, F#, C#, G#(Aflat), D#(Eflat), A#(Bflat) and back to C. Using twelve pure fifth, the exact 2:3 relationship, results in a slight overshooting of seven octaves producing a spiral of fifths. Equal temperament corrects the small comma by squeezing the 2:3 relationship to approximately 2:2.996.

diatonic - Scales constructed principally of (whole) tone intervals (t) - i.e. two semitones (st); normally containing seven notes or degrees of the scale. The major scale being: C t D t E st F t G t A t B st C and the minor scale: A t B st C t D t E st F t G t A.

difference tones - see combination tones.

- dimension** - An independent axis of freedom. The three familiar spacial axes of the material world: left-right, front-back and up-down are complemented by the time axis, past-future.
- diminished** - An interval reduced in compass by a semitone or a chord containing such an interval.
- dissonance** - The inverse of consonance, an awkward sound. See consonance. By Euler's definition a chord with a large LCM relative to the frequency ratios of its constituent notes.
- dominant** - The 5th degree of the diatonic scale, denoted 'V'. Thus C I, D II, E III, F IV, G V, A VI, B VIII.
- duple meter** - A (simple) meter consisting of two pulses, a stressed beat followed by an unstressed beat.
- electron** - A negatively charged particle normally held in orbit about the positively charged nucleus of an atom. See fundamental matter particles.
- elements** - The first 30 elements in the Periodic Table in atomic (proton) number order: 1 hydrogen H, 2 helium He, 3 lithium Li, 4 beryllium Be, 5 boron B, 6 carbon C, 7 nitrogen N, 8 oxygen O, 9 fluorine F, 10 neon Ne, 11 sodium Na, 12 magnesium Mg, 13 aluminium Al, 14 silicon Si, 15 phosphorus P, 16 sulfur S, 17 chlorine Cl, 18 argon Ar, 19 potassium K, 20 calcium Ca, 21 scandium Sc, 22 titanium Ti, 23 vanadium V, 24 chromium Cr, 25 manganese Mn, 26 iron Fe, 27 cobalt Co, 28 nickel Ni, 29 copper Cu, 30 zinc Zn.
- entropy** - A measure of the level of disorder in a system. It is equivalent to a measure of the amount of information in a system. A system with a high level of entropy contains little structure and differentiation, and tends toward a uniform, random and homogenous character, whereas low entropy denotes an interesting and complex structure with significant information content.
- equilibrium** - The condition of a system which has reached its maximum level of entropy or equality with its surrounding environment.
- equal temperament** - A scheme of tuning the 12 notes of the chromatic scale - i.e. semitones, as equal pitch divisions of the octave.
- Euler** - Leonhard, (pronounced 'oiler') influential 18th century Swiss mathematician. Euler's theory of harmony underlies the idea of a 'Metric' presented in Journey to the Heart of Music.
- feedback** - The property of a system to act upon itself and so affect or alter the course of its own development. Negative feedback has the effect of correcting, turning back or 'decelerating' the changes a system is experiencing, while positive feedback intensifies them. It would be a negative feedback loop that produces an upward cycle of fifths, that is, a checking of the spiral effect of a pure 2:3 relationship.
- figured bass** - A shorthand tabular method for representing the harmonic structure of a piece from a bassline with numbers placed below the staff indicating the main harmonic intervals relative to the bass notes. Developed at the close of the renaissance, it formed a influential part of baroque technique.
- flat sign** - A notational sign lowering a note's pitch by one semitone.
- Fourier, J.B.J.** - (1768-1830) French mathematician who, in the theorem bearing his name, demonstrated that any complex wave could be reduced to a number of constituent simple waves.
- frequency** - abbr f, A measure of the number of oscillations or waves per unit of time, measured in hertz (cycles per second), abbr Hz. In music, the alternative term 'pitch' is generally used when referring to the frequency of a note.
- fundamental matter particles** - Current theory and experiment suggests the existence of twelve elementary particles of matter, the majority of which are unstable in the relatively cool conditions prevailing in

the present day universe. Virtually all matter consists of stable particles from 'Family 1'.

	:	Family 1	:	Family 2	:	Family 3	:
Leptons	:	Electron-neutrino	:	Muon-neutrino	:	Tau-neutrino	:
"	:	Electron	:	Muon	:	Tau	:
Quarks	:	Up-quark	:	Charm-quark	:	Top-quark	:
"	:	Down-quark	:	Strange-quark	:	Bottom-quark	:

Quarks are not found in isolation, but in combinations of two or three. Protons are formed from two up-quarks and one down-quark and neutrons from two down-quarks and one up-quark. Atoms are made up of a nucleus containing protons and neutrons surrounded by an 'electron cloud'.

galant style - A lighter style of music which developed in the eighteenth century, in part as a reaction against the 'heaviness' of the later baroque style.

glissando - A non-discrete passage of smoothly varying pitch.

group theory - An area of mathematics dealing with collections of (mathematical) objects which share some common feature, for example, whole numbers or the rotational symmetries of a square. See Chapter 17.

harmonic - A sound with a frequency relationship of a whole numbered multiple to a fundamental tone. Almost all notes consist of a perceived fundamental pitch plus an array of much fainter harmonics.

harmonic series - The sequence of natural, whole number, resonant states of vibration of a perfect oscillatory system. They are labelled from the fundamental frequency: $h_1, h_2, h_3, \dots, h_n$. The first six harmonics produce the common major chord: CCGCEG and the first eight, the chord of the dominant 7th (of the key of F major): CCGCEGA#C.

hemiola - literally 'one and one half' - A switching about between levels of rhythmic groupings and subgroupings, such that, two groups of three are swapped from three groups of two (or vice versa). The alteration of accent, typically from $\underline{1}, 2, 3, \underline{1}, 2, 3$ to $\underline{1}, 2, \underline{1}, 2, \underline{1}, 2$; is often found approaching a cadence. It is modulation in a metrical form. Both the overall period of six beats and the fine graining of individual beats remains constant (in logical units), whilst the distribution of accents among the individual beats is reorganised, from a $6/8$ (or $6/4$) meter to the lower energy level of a $3/4$ (or $3/2$) meter. This device is often accompanied by tempo alterations which accentuate the loss (or gain) of energy - however the principle is clearly represented by the unchanging logical units of duration.

hertz - abbr Hz, cycles or oscillations or vibrations per second.

heterophony - A layered texture of parts often containing simultaneous but different renditions of the same material.

homophony - A uniform texture of parts often consisting of a simple chordal accompaniment to a melody.

information - Configurations or arrangements of matter/energy. See entropy.

interference pattern - A recurring pattern of fluctuations produced by the amalgamation of two or more simple waves into a more complex waveform. A likeness is drawn between interference patterns and metrical patterns in *Journey to the Heart of Music*. For interference patterns to be stable, the constituent waves must be 'coherent', that is of fixed frequency, wavelength and phase relationship.

interval - The distance in pitch between two notes.

inversion - Harmonic Inversion: traditionally a chord without its root note in the lowest position. However in *Journey to the Heart of Music* an additional conception of harmonic inversion is introduced involving the conversion of harmonic relationships of frequency to arithmetic relationships. See Chapters 11 and 14. Melodic Inversion: traditionally the reversal of pitch motion, a melody

progressing in identical intervals but with the intervalic changes moving in the opposite direction. In addition to which music theory has long recognised the temporal inversion (time direction) of melody, see retrograde, but not the temporal inversion of harmony, -i.e. playing it backwards.

key - A network of relationships that emerges in music from the sense of a tonal 'centre of gravity' - a 'fundamental' note at the centre of a web of interrelationship. It is helpful to think in terms of individual 'keys' from a piano keyboard. There are 12 different 'keys' on the keyboard - C, C#, D, D#, E, F, F#, G, G#, A, A# & B - repeated in each octave (discounting enharmonic variants). Using any one of these 'keys', it is possible to construct a variety of scales (beginning on the 'key') such as a major scale or a minor scale and many other 'modes'. Each of these scales or modes - different arrangements of notes starting from the 'key' note - can be viewed as subsets, inflections or flavours of the one tonal centre. All the subsets owe an allegiance to the fundamental 'key' note. Thus C major is a web of relationships founded on the 'C key' and using predominantly the major scale arrangement of notes. While Beethoven's Moonlight Sonata in the key of C# minor is founded on the 'C# key' and uses mainly the minor scale note arrangements built on C#.

key signature - One or more sharps or flats placed at the beginning of the staff so as to alter the pitch of the line or space which they occupy by one semitone upward for sharps and downward for flats.

leading note - The seventh note of the diatonic major scale, which exhibits a strong affinity for the tonic note above, a semitone higher. To a lesser degree the fourth note of the diatonic scale also shares this characteristic, tending to fall by a semitone to the mediant or third note of the scale. These two leading notes combine in the forceful dominant-tonic full cadence (V⁷- I).

toy worlds - model worlds, thought experiments.

Lowest Common Multiple abbr. LCM, the smallest number into which a given set of numbers can be divided individually without remainder.

little world - A model - a Little World of relationships. Essentially, the Modulating Oscillatory System general relational model consists of relationships and a process by which the relationships can be changed (see group theory). The relationships are arranged as two or more entangled harmonic (or arithmetic) series, one a fundamental 'nesting' series, within which the other nested series reside. The mechanism whereby the constituent series interact is 'modulation'; it is in principle the same process as that used in music to change from one key to another. In computer terms, the nesting and nested series are the data, and the algorithm or rule which acts upon them is modulation.

major - The term applied to scales, chords and keys where the pitch interval between the fundamental note and the third note is four semitones -i.e. the ratio of 4:5, eg C-h4 and E-h5 of the harmonic series.

measure - The principal metrical unit in music. A recurring (time) period with a regular pattern of accentuation denoted by the time signature, e.g. 3/4 or 4/4. Normally, the measure (sometimes termed bar) will be divided into as many sub-units (beats) as shown by the numerator of the time-signature, the upper number.

meter/metre - The grouping of stresses into regular recurring patterns which in music form the basis of the bar or measure. In Journey to the Heart of Music the concept of meter is extended to include interference patterns formed by oscillatory systems and the term 'Metric' is given a capital to distinguish this particular usage.

Metric - Strictly 'Euler's Metric' is defined as the lowest common multiple of the constituent frequencies in a system, expressed in relative terms. And abbreviated to 'M' plus the LCM of the frequencies, e.g. M12 (h1, 2, 3, 4 – LCM=12) or M6 (h3, 6, 9 in relative terms h1, 2, 3 – LCM=6).

- metronome** - A device which indicates tempo by sounding a regular 'tick'. The time divisions of a minute are denoted as, for example, 120MM indicating ticks at half second intervals. The letters MM stand for Malzel metronome, named after its inventor, Malzel.
- minor** - The term applied to scales, chords and keys where the pitch interval between the fundamental tone and the third note is three semitones -i.e. the ratio of 5:6, eg E-h10 and G-h12 of the harmonic series.
- mode** - An arrangement of note pitches within a scale. Thus the major and minor scales could also be termed the major and minor modes, however, the term is used most often with regard to the seven medieval modes (scales) where the modern major scale translates to the Ionian mode and minor to the Aeolian mode. The particular arrangements of tones and semitones of the other four (church) modes can be obtained by playing 'white' notes covering an octave on a piano keyboard, the Dorian D to D, Phrygian E to E, Lydian F to F, the Mixolydian G to G and the fifth largely theoretical Locrian mode B to B. The term mode is also applied to other scales such as five note pentatonic scales.
- modulation** - In music, the term 'modulation' is generally used to refer to the change from one key or 'tonal centre of gravity' to another, e.g. from C major to G major. But this is only one example of a more general phenomenon found at many levels of music and perhaps in other oscillatory systems as well. Traditionally, music theory has adopted a predominantly descriptive approach involving 'pivot' chords common to both keys. However, another more general, analytically based, computational understanding of the process is possible, by focusing on the basic parameters of frequency, wavelength and energy. In *Journey to the Heart of Music* the term 'modulation' is used generically to denote a process of exchange/transformation between harmonic (or arithmetic) series. For harmonic series, the exchange can be of a greater number of ratios founded on a lower fundamental frequency, for a lesser number of ratios founded on a higher fundamental (releasing energy/information) or a lesser number of ratios founded on a higher fundamental, for a greater number of ratios founded on a lower fundamental (absorbing energy/information). For arithmetic series, the exchanges are vice versa.
- monody** - A melodic form of music where other elements are subservient to the melody. In particular the term refers to a style of late renaissance song which purported to imitate the musical principles and practices of ancient Greece. This monodic style was to develop into the operatic recitative and figured bass practice central to baroque music.
- monophony** - Unaccompanied melody.
- n~** - abbreviation for 'nesting' e.g. M6n~M2 a metrical pattern of three beats each of which 'nests' (contain) two sub-beats - 6/4 or 3/4 time signatures.
- natural sign** - A notational marking cancelling a sharp or flat sign.
- nested** - An arithmetic or harmonic series is nested when all of its terms (h1, 2, 3, etc.) form a subset of another (nesting) series.
- nesting** - A nesting arithmetic or harmonic series is a more fundamental series out of which a subset of its own terms forms the whole set of a less fundamental (nested) series.
- neutron** - An electrically neutral particle found in the nucleus of an atom. A neutron is slightly heavier than a proton. The neutron is formed from two down-quarks of electromagnetic charge -1/3 each and one up-quark of charge +2/3. This combination gives it a zero electric charge overall. Outside the nucleus of the atom the neutron is unstable, decaying into a proton and electron plus a small amount

of energy.

nucleus - The central core of an atom containing protons and neutrons. Within the nucleus a maelstrom of activity is found, as neutrons decay into protons and protons absorb energy to form neutrons - a vibrant dance of quarks - but with the outcome of overall stability at the level of the whole nucleus. The core of an atom is an active structure of resonant states, not a passive container.

octave - An interval spanning eight (diatonic) notes, with the overall ratio of 1:2. Thus the eighth consecutive note of a major scale: C, D, E, F, G, A, B and C; returns to the same letter name, C, with a frequency twice that of the starting note, C. The octave relationship is that of the power of 2 and so in a harmonic series we find: C-h1, C-h2, (G-h3), C-h4, (E-h5),... C-h8,... C-h16, etc.

orbitals - See shell/sub-shell.

organum - A medieval style of polyphonic music in which additional vocal parts are used to embellish a plain chant melody. These pieces mark the beginnings of the western harmonic tradition.

oscillation - periodic behaviour, often of regular frequency and usually measured in cycles per second - hertz, abbr. Hz.

passing note - A non-harmonic note which usually derives its existence from the motion of the part within which it appears, eg. scalewise movement, normally resolving by stepwise motion to a harmonic note. Passing notes may occur on or off the beat and are thereby termed accented or unaccented passing notes.

perfect fifth - Two notes or frequencies of ratio 2:3, e.g. notes C and G.

period - The time taken for one complete vibration or wave cycle.

periodic table - A chart of the elements, originally devised by Dmitri Mendeleev in 1869. The table is set out in order of ascending atomic number (number of protons in the nucleus) and arranged so that elements with similar properties fall into vertical column 'groups'. This produces seven horizontal rows - the periods. The similarity of character found in the vertical groups of elements, is largely the result of a repeating pattern of electron configuration in the outermost structural layer.

phase - The position within a cycle of oscillation, normally measured in degrees or radians. Two points 360 degrees (one wavelength) apart oscillate in phase, describing the same motion at the same time.

photon - The smallest unit of electromagnetic energy, a quantum of light.

pitch - An alternative term for note frequency.

plain chant/song - The tradition music of the Latin church codified in the time of Pope Gregory I (590 - 604 AD). From the pre-existing body of plain chant cantus firmi were selected and used as the basis for the first developments in polyphonic music, -i.e. organum.

polyphony - Music with many parts or voices.

proton - A positively charged particle normally found in the nucleus of an atom. The proton is formed from two up-quarks of electromagnetic charge $+\frac{2}{3}$ each and one down-quark of charge $-\frac{1}{3}$. This combination gives the proton an electric charge of +1.

progression - A satisfying and musically logical sequence of chords. From the point of view of a mutable number analysis of music, chord progressions form valid digit sequence exchanges within a single magnitude.

Pythagorean comma - see comma.

quantum/quanta - The smallest discrete unit allowed or possible.

quark - see fundamental matter particles, proton and neutron.

resolution - The movement from a harmonic structure and mutable digit sequence of greater complexity to

shell/subshell - Structures, akin to standing waves and related to levels of energy, formed by electrons as they cluster about the nucleus of an atom.

Periods	1	2	3	4	5	6	7	8
Shells	1st	2nd	3rd	4th	5th	6th	7th	8th
Subshells	1s	2s, 2p	3s, 3p, 3d	4s, 4p, 4d, 4f	5s, 5p, 5d, 5f	6s, 6p, 6d	7s, 7p	8s
Num. of Orbitals	1	1, 3	1, 3, 5	1, 3, 5, 7	1, 3, 5, 7	1, 3, 5	1, 3	1
Electrons/Orbt	2	2 6	2 6 10	2 6 10 14	2 6 10 14	2 6 10	2 6	2
Total Electrons	2	8	18	32	32	18	8	2

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The lowest level of structure in the 'electron cloud' is the orbital which contains two electrons of opposite spin - one spin 'up' and one spin 'down'. The next level of structure is the subshell which has four effective forms. The 's' (sharp) subshell containing one orbital, the 'p' (principal) subshell containing three orbitals, the 'd' (diffuse) subshell containing five orbitals and the 'f' (fundamental) subshell containing seven orbitals - the names derive from the characteristics of the emission spectra. The top level of structure is the shell.

spin - A quantum scale quality intrinsic to particles and analogous to rotation.

staff - The (usually) five lines and four spaces upon which music is written, also sometimes called a stave.

standing/stationary waves - The interference patterns formed by simple waves confined within a system.

Only constituent simple waves, with whole number relationships to the natural resonance of the system, will tend to reinforce themselves and thus survive to contribute to the formation of the combined complex oscillation - the interference pattern.

subdominant - The note or chord on the fourth degree of the scale. Musically the subdominant functions as the antithesis of the dominant on the fifth degree, introducing an element of repose and inaction, in contrast to the drama and motion encapsulated by the dominant.

summation tones - see combination tones.

suspension - The holding over of a note from a former harmony which clashes with, and then resolves into, the current chord.

syncopation - The disturbance of the regular metrical pattern by placing accents on normally unaccented beats.

thermodynamics - The 2nd Law of Thermodynamics states that the total entropy (the measure of a system's disorder) of a close system will always tend to increase.

timbre - The tone quality or 'color' of a sound produced by the pattern of higher frequencies and somewhat analogous to the harmonic information carried by the lower frequencies of notes and chords.

time signature - Two numbers, a numerator and denominator, placed on the staff at the beginning of a score (and sometimes at later points of change in the meter). The lower part of the fraction, the denominator, indicates the unit of measurement - halfnote, quarternote, eighthnote - while the upper part, the numerator, determines how many units of measurement occur in one period of the meter. There is one other essential element the Metronome mark MM to link the *logical* time of the unit of measurement, the denominator, to the *hard-time* of minutes and seconds. Thus a meter of 4/4 (4 quarternotes per bar) at a rate of 60 quarternotes per minute indicates a metrical unit of measurement (quarternote) of 1 second and a metrical period of 4 seconds per bar.

tonal centre - see key.

tonality - The gravitational-like pull of a key. More broadly the musical sytem of key relationships which developed in European music reaching its zenith in the eighteenth century, -i.e. Bach to Beethoven.

tone-color - See timbre.

tonic - The 1st degree of the scale, the key note or tonal centre. The tonic or fundamental frequency and its octaves (powers of two thereof) is the 'centre of gravity' and principal point of reference, in tonally organised music.

transient sound - Disordered sound. The characteristic make up of natural sound, that is, chaotic collections of more or less unrelated and rapidly changing frequencies. Musical sound is very much

the opposite: steady frequencies related by simple low number ratios. The ear is very sensitive to transient sound as it is vital for the detection of sound direction. Individual notes begin with a starting transient as the vibrating medium, string, air column, etc. comes into equilibrium. It is from this 'attack' that the ear gleans most information about the nature of the sound source.

triad - A three note chord consisting of a root note plus two intervals of a third. The major triad has (in ascending order) a major third plus a minor third, the minor triad a minor third plus a major third and the diminished triad two minor thirds (the triad on the leading note). This latter triad is generally interpreted as a dominant 7th chord without its root note - G in the key of C major - and its position, built on the leading note emphasises the resolution to the tonic, which help to give focus (and limits) to the key. We judge triads to be either major or minor principally by the character of the first interval above the root note and we also assess other combinations of notes in this upward direction.

triple meter - A (simple) meter consisting of three pulses, a stressed beat followed by two unstressed beats.

tritone - An awkward interval of six semitones, ratio 45:64, which notably occurs in the dominant-seventh to tonic cadence (V⁷- I).

unison - A interval of two tones consisting of one and the same note, an interval of zero semitones.

voice leading - The natural movement of parts as dictated by the harmony which enfolds them.

wavelength - The distance from one wave peak to the next, the length of the wave. The 'arithmonic' nomenclature (abbr 'a') used in Journey to the Heart of Music in an analogous fashion to 'harmonic', represents terms in a wavelength series, a sequence of whole number wavelength relationships.

whole tone - An interval of two semitones, the most common interval in the diatonic scale. When a scale consists exclusively of whole tones (as like the twelve tone scale of only semitones) it loses the power to clearly define a sense of key.

