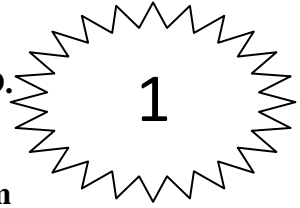


Mathematical Aspects in Music

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Abstract :

The sound of music can be explained mathematically using symbols and numbers. Mathematics plays a pivotal role in music Harmony. Harmony is a combination of musical sounds as perceived by the ears and is analyzed in terms of mathematics based on concepts such as frequency, pitch, tempo and rhythm. Music theory analyses the pitch, timing and structure of music .It uses mathematics to study elements of music such as tempo, musical form and meter or Rhythm. Mathematics and music are closely related. Mathematics is seen in the form of notations and symbols created by composers and musicians which are the melodic sounds. . Golden Ratio in music is approximately 1.618 which is a mathematical number. All the laws of vibration of musical instruments comes under Science In Performing arts like music it is about counting time, beats per minutes and formulaic progression which therefore reinforces parts of brain in use as like solving problem in Mathematics .Studies shows that the children who can play musical instruments are all able to complete complex mathematics problems than ones who do not play musical instruments. Sarva laghu is seem less, steady flow expresses hidden mathematics, But the Kanakku in percussion instruments like mridangam explicit mathematics through calculated rapid beats and pauses. . Mathematics used extensively in the design and construction of musical instruments .Totally all musical Instruments are constructed purely on mathematics that is with length, height, breath measurements through Engineering ..

Keywords: Counting – Octaves – Prasthara – Rhythm – Tonal system – Tuning system.

Introduction:

Music theory analyses the pitch, timing and structure of music .It uses mathematics to study elements of music such as tempo, chord program, musical forms and meter or Rhythm. . In Performing arts like music it is about counting time, beats per minutes and formulaic progression which therefore reinforces parts of brain in use as like solving problems in Mathematics .Studies shows that the children who can play musical instruments are all able to complete complex mathematics problems than ones who do not play musical instruments. So all the musicians are mathematicians who are using their brain without knowing.

Philosophy and Music:

The Philosophers (569 – 475) often referred to as the father of Numbers. They also considered as the father of Harmony given that discovery of over tones series. Mathematics plays a pivotal role in music Harmony. Harmony is a combination of musical sounds as perceived by the ears and is analyzed in terms of mathematics based on concepts such as frequency,pitch , tempo and rhythm .Many of the ancient Philosophers considered music a branch of Mathematics .

Mathematics used in Music:

Counting of numbers , Beats ,Scales, octaves , sruthis , Pause or rests ,music patterns and rhythmic patterns , Symbols, Harmonies, time signature , overtones ,tones ,pitch , sympathetic vibrations are calculated through Mathematics.

Mathematics is seen in the form of notations and symbols created by composers and musicians which are the melodic sounds.

Golden Ratio in music: It is approximately 1.618. Mozart designed his Piano sonatas to approximately 1.618, the golden ratio number.





Pythagoras discovered that beautiful relationship between the notes was also mathematical relationship. Pythagoras also discovered that musical intervals could heal, cure diseases. These musical intervals are mathematical numbers

The percussion instruments uses more mathematical oriented sections both in learning and in performances.

Mathematics and Musicians:

Albert Einstein is a scientist, musician, violinist and pianis .

Abdul kalam is a scientist and a veena player.

Sir C.V.Raman is a scientist and a musicologist.

Tamil poets Thirugnana Sambandar (Thiru Ezhukutrirkkai and many rhythmic varieties), Thirunavukkarasar, (Thirutthandagam) Thirumangai azhwar, and Nakkirar (Thiru Ezhukutrirkkai), Arunagiri nadar (Rhythmic Thirupugazh) incorporated both music and mathematics in their Hymns

Pythagoras is a mathematician and musicologist.

Mozart is musician come Mathematician

Counting: In music counting is a system of regularly occurring sounds that serve to assist with the performance or audition of music by allowing the easy identification of the beat .Commonly this involves verbally counting the beats in each measure as they occur. Music is considered both an Art and science because it makes use of mathematical principles and logic. Musical composition is a mathematical exercise for practice. Instead of numbers it uses sounds, tempos and pitch to create melody. We use counting to show the tala or rhythm. Counting is used to start a program, group singing to coordinate everybody Counting numbers is used for anagata graha and pause or rest in between the musical forms .

Mathematics in Musical Octaves: According to carnatic music there are five Octaves. But a singer can sing only three octaves normally. Only Musical Instruments can show all the octaves .An Octave is an interval between 2 pitches where one has a frequency or rate of vibration that is twice of the other The relationship m can be expressed as the ratio 2 : 1. When the frequency is multiplied by two the note remains the same. For example for the note S (Satjam) if the sound vibration of S is 4 the sound vibration on the upper octave will be 8 and the sound vibration of lower octave will be 2 .In the lower Octave this number is divided by two but the S note remain the same .

Rhythm and Beats: There is no rhythmic pattern without number. Music has been divided into sections called measures or talas. Each tala has equal number of beats or counts .We can compare this divisions in mathematics particularly in times. In music each piece has a time signature or tala which gives the information about its rhythm and beat. Heart beat is a perfect rhythm in beats which is a natural one called Aagata Nada. All the other rhythmic beats created by human are Anagata Nada.

Music and Poems: The relation between the poetry and music is mathematical. All poems has limited number of lines in a stanza. Each line has limited number of syllables or letters. Almost all poems and compositions are constructed with rhythm which is a mathematical pattern. Especially in Thirupugal which is a rhythm based poetry, each poem will definitely follow one particular rhythm (chandam)with restricted letters which will be prescribed on the top. Chandam strictly follows mathematics. Mathematics also helps in reading music that is the notations with Time signature. The biggest similarity between music and mathematics is the patterns .Music has repeated verses and phrases using Mathematics. Music involves creating patterns of sound whereas mathematics is the study of patterns.

Musical forms: Musical forms are the simple extension of small piece of music. This is also used in Architecture by which short pieces extended to form a design or structure. In constructing musical form musician is often considered like an architect. The composer construct a musical form with (melodic scales of that particular raga) melodic phrases in different octaves, gamakas, pauses ,divine words with repetitions to a particular tala .These are the building blocks of that musical form and to construct this one need mathematical knowledge ..





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Tuning Systems: There are two types of tuning system. They are Equal Temperament and Just Intonation. Equal temperament simplifies things by making the octave only through pure intervals. It is then divided into 12 equally spaced half steps in equal temperament the semi tone is measured at 100cents. The Just Intonation has two different definitions. The first one is ancient and strictly mathematical. It says that Just Intonation is a method of tuning intervals and scales based on exclusively on rational number. The second one is modern and strictly acoustics. It says that Just Intonation is a method of tuning based on the intervals of the harmonic series. If we write the conventional 12 tones chromatic scale the sequence result will be $1\backslash 1, 16\backslash 15, 9\backslash 8, 6\backslash 5, 4\backslash 3, 45\backslash 32, 3\backslash 2, 8\backslash 5, 5\backslash 3, 16\backslash 9, 15\backslash 8, 2\backslash 1$.

Tonal system: The twelve tone techniques also known as the dodecaphony. The basis of 12 tone technique is the tone row, an ordered arrangement of the twelve notes of the chromatic scales which are derived from seven full tones .Here it is not about frequency it is because of spaces or intervals between the notes. So familiar pieces of music are entirely because of these interval. In Indian music they are called 12 semi tones .(s, r1, r2, g1, g2, m1,m2, p ,d1 ,d2 , n1 , n2) The scales further divided into 22 notes (sruthis) All sruthi calculations are completely made up of mathematics .

Prasthara : It is one of the ten elements seen in Tala dasa Prana . It is expanding the tala in a particular way. Expansion is executed in the mode of permutation and combination. The units of time in different ways to form a particular tala. The permutation and combination are executed in a particular order so as to avoid the same form of permutation according more than once .There are short cut methods for ascertaining the possible numbers of permutation and combination. And for ascertaining the order of a particular combination when the form is given and the form of a particular combination when the order is given. The number of combination between two fixed limits are also calculated by means of formulae. So Prasthara is completely a Mathematical program.

Mathematics and Percussion Instruments (Mridangam) : The basic simple building blocks structures like rhythmic beats , farans ,rapid drum rolls, punctuating resonant pauses are heavy mathematical ones. The mathematical structure of talas has Aksharas , (units) Jathis , counts (laghus) , beats , Aavarthas (cycles) Kala, Tempo , which are expressed in mathematical numbers . The resolution of landing points are the peak in a tala which are called Thirmanam shows complex phrases in rhythm. The highly mathematical complex sequences like Moharas , farans, are seen in percussion section in Indian music . Srva laghu is seem less , steady flow expresses hidden mathematics which attracts many . But the Kanakku in percussion instruments like mridangam explicit mathematics through calculated rapid beats and pauses. Speeds in tala comes under tala dasa pranas also a mathematical one. First speed, second speed, third speed and executing Tisram (follow the pattern of three) and kadam (follow the pattern of five) also shows the mathematical efficiency of that person.

Musical Instruments and Mathematics:

Without vibration there is no sound at all. So the laws of vibration of musical instruments comes under Science. In stringed instruments the sound is directly proportional to tension of the string and inversely proportional to the length and thickness of the string. In wind instruments the sound is directly proportional to the air pressure blown on the pipe .and inversely proportional to the length of the instrument. So these are all based on the calculation of mathematics and physics. Mathematics used extensively in the design and construction of musical instruments .Totally all musical Instruments are constructed purely on mathematics that is with length, height, breath measurements. The fixation of sound post in Violin, the fixation of wax frame with frets on Vina are purely mathematical The fixation of mouth hole and finger holes are in flute and in other wood wind instruments is by mathematical calculations . The mathematical principle underlying the Piano's design and tuning are crucial to its functionality and the sound it produce.



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Conclusion:

The net result without mathematic knowledge music cannot be created so if you are a musician then you are a mathematician too. Sense of music hide subliminal calculations which is a stimulus or mental process below the threshold of sensation on consciousness perceived by or affecting someone's mind without being aware of it . Mathematics and music are closely related. . Mathematics plays a pivotal role in music Harmony. Harmony is a combination of musical sounds as perceived by the ears which is analyzed in terms of mathematics based concepts such as frequency, pitch, tempo and rhythm. Mathematics used extensively in the design and construction of musical instruments .Totally all musical Instruments are constructed purely on mathematics that is with length, height, breath measurements through Engineering. So the Mathematics in the form of Engineering is used extensively in the design and construction of musical instruments. Music involves creating patterns of sound whereas mathematics is the study of patterns.

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