Wenger Corporation
Planning Guide Content Certification

Reference Materials
for
Part I, Sessions 1,2,3

June 2-4, 2004

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Presenter Certification Part I

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2. Dissonance & consonance
3. Beat and Rhythm
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8. Articulation & Phrasing terminology
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15. Musicians terms for a variety of tone colors
16. Critical Listening 500 COL/UNIV.
17. Types of musical works AN ACCREDITION ORGANIZATION
18. Professional Musical organizations (MENC, NASM, MEA, CMS, NAMM, etc.) COLLEGE MUSIC SOCIETY
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6. Consultants – Acoustic, Theatre.
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4. Sound Waves & Wave length
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9. Mass Law
10. STC, NIC, NC, NRC.
11. Presence & envelopment
12. Brightness & warmth
13. Echos & Flutter echoes
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Presenter Certification Part I

Session #2, Architectural Acoustics from the Musicians Perspective.

Four hours.

A. The nature of musical sound

1. How is sound produced with instruments and in the human voice?
    a. Strings
    b. Woodwinds
    c. Brass
    d. Percussion
    e. Human Voice
2. What is unique about musical sound?
    a. Understanding loudness
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    c. Pure tones vs. Complex tones – The Harmonic Series
3. What are sound waves, and how do they behave in an architectural space?
4. Direct vs. reflected sound.
5. Sympathetic vibrations
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7. Reverberation times. How do we measure them, and what do we recommend?
8. Overtones & the unique Timbre of each musical instrument
9. Musical notation vs. scientific notation of musical sound

B. How does the space influence what the musician hears?

1. The impact of cubic volume. Too little, too much, & just right.
2. Coupling room volume below risers, & above suspended ceilings
3. Recommending Room shape
4. Good sound Isolation – Past practice
5. The wisdom of buffer zones. Also double sets of doors for main entrances.
6. Masking, and the impact of poor sound isolation….on soft sounds – on pitch.
7. Interior wall, ceiling, and floor treatments – How do these building materials impact musical sound?
8. Absorption and Diffusion
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10. The "Thick/Thin Rule", and the exception to the rule.
11. The right type of suspended ceiling.
12. Windows and drapes
13. Avoiding noisy mechanical systems.

Presenter Certification Part I

Session #3, Music Suite Floor Plans, Storage and Equipment planning, plus a review of literature relevant to Music Facility Design.

Four hours.

A. Music Suite Floor Plans

1. Rehearsal Room size. Seating Plans & requirements for Bands, Orchestras, & Choirs.
2. Evaluating Space and Acoustic Requirements
3. Traffic Flow
4. Teacher Monitoring

B. Planning for Practice Rooms

1. How many? – Conservatories, College Music Departments, High Schools
2. Practice Room requirements

C. Other Spaces

D. Storage Planning

1. Floor Space
2. Security
3. Humidity & temperature

E. Equipment Planning

F. Key Literature

1. Wenger Planning Guide for Secondary School Music Facilities
2. An Acoustic Primer for Music Spaces - Wenger
3. Music Facilities: Building, Equipping, and Renovating. Harold Geerdes. MENC
4. Planning New or Renovated Music Facilities. Howard, Boner, Holden, Wetherill. NASM
5. Architectural Acoustics. Egan. McGraw Hill

Mike Smedstad
5/2/04

Helpful Hotlinks to Music, Facilities, & Acoustics Websites:

These hotlinks provide a wealth of information. It is highly recommended you save these sites as favorites on your computer.

Music Dictionaries

http://library.thinkquest.org/2791/MDOPNSCR.htm	Good Basic
http://www.dolmetsch.com/defsa.htm	Includes more obscure
http://www.music.vt.edu/musicdictionary/	Voice pronounces

Music Sites

http://www.teoria.com/	Music Theory
http://ccrma.stanford.edu/software/cmn/cmn/cmn.html	Musical Notation
http://library.thinkquest.org/C001468F/library/theory/3greatstaff.htm	Great Staff
http://music.theory.home.att.net/insrange.htm	Instrument Ranges
http://www.8notes.com/articles/instrument_ranges.asp	Instrument Ranges
http://www.dolmetsch.com/musictheory29.htm	Instrument Ranges
http://www.musicalintervalstutor.info/listenpg.html	Listen to Intervals
http://www.csupomona.edu/~dmgrasmick/mu100/wb/NoteNames.pdf	Note Names
http://music.kibisis.com/kibisis/music/Orchestra_Set-Up.asp	Orchestra seating

Acoustics Sites

http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u1111a.html	Physics of sound
http://asa.aip.org/index.html	Acoustic Society of America
http://www.phys.unsw.edu.au/~jw/hearing.html	Equal Loudness Tester
http://www.phys.unsw.edu.au/music/basics.html	Music Acoustics Basics
http://www.phys.unsw.edu.au/music/sound.spectrum.html	Sound Spectrum
http://www.tufts.edu/as/wright_center/physics_2003_wkshp/book.htm	Music Physics
http://www.public.coe.edu/~jcotting/tcmu/	Acoustic Society - Music
http://www.physicsclassroom.com/mmedia/waves/swf.html	Standing Wave
http://www.uvcuring.com/faxinfo/noise/noise.htm	OSHA Noise levels
http://64.233.167.104/search?q=cache:FYHhO7V6P2AJ:www.mvcc.edu/~jfiore/audiotech/lectures/BasicAcoustics.doc+speed+of+sound+is+1,130+fps&hl=en	Sound Basics

Theatre Glossaries:

http://www.dramatic.com.au/glossary/	Theatre Terms
http://www.schoolshows.demon.co.uk/resources/technical/gloss1.htm	British

Music Basics Vocabulary

Allegro	Quick and lively
Andante	Moderate speed
Moderato	Moderately slow
Tie	A curved line that connects notes of the same pitch
Da Capo	Go back to the beginning
Slur	A curved line that indicates notes to be played without tonguing or in one bow
Ritard	Gradually slow the tempo
Solo	One person plays
Ensemble	A group usually playing different parts
Fine	Finish or end
Chromatic	Music that moves in half steps
Interval	The distance between two notes
Simile	Continue in the same manner
Tempo	The speed of a piece
Crescendo	To gradually play louder
Diminuendo	To gradually play softer
Flat	Lowers a note a half step
Sharp	Raises a note a half step
Natural	Cancels a sharp or a flat
Etude	A piece of music written specifically to present certain technical difficulties to the player
Theme	A melody that is an important part of a larger work.

Basic glossary of musical forms

These definitions are taken from the glossary of the The Classical Music Navigator by Charles H. Smith

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air/ayre: English style of song popular in the late 16th and early 17th centuries; usually accompanied by a lute.

aleatory music: music composed according to various principles introducing chance or indeterminate outcomes into its actualization in performance.

anthem: a choral setting (often with solo voice parts and organ accompaniment) of an English language religious or moral text, usually for performance during Protestant services; c1550 to present.

antiphon: a liturgical chant sung as the response to the verses of a Psalm; generally fairly short and simple in style.

arabesque: a short piece of music featuring various melodic, contrapuntal or harmonic decorations.

bagatelle: a short, light instrumental piece of music of no specified form, usually for piano.

ballade: (1) a 14th/15th century French song form which set poetry to music; (2) an instrumental (usually piano) piece with dramatic narrative qualities.

barcarolle: song or instrumental piece in a swaying 6/8 time (i.e., suggesting the lilting motion of a Venetian gondola).

berceuse: a soft instrumental piece or lullaby, usually in a moderate 6/8 tempo; a lullaby.

canon: a contrapuntal form in two or more (voice or instrumental) parts in which the melody is introduced by one part and then repeated by the next (and so on) before each previous part has finished (i.e., such that overlapping of parts occurs).

cantata: term applied to a 17th and 18th century multi-movement non-theatrical and non-liturgical vocal genre; subsequently used to describe large-scale vocal works in the same spirit, generally for soloists, chorus and orchestra; may also be for solo voice and accompaniment.

canzona: (1) 16th/17th century instrumental genre in the manner of a French polyphonic chanson, characterized by the juxtaposition of short contrasting sections; (2) term applied to any of several types of secular vocal music.

caprice/capriccio: term describing a variety of short composition types characterized by lightness, fancy, or improvisational manner.

carol: since the 19th century, generally a song that is in four-part harmony, simple form, and having to do with the Virgin Mary or Christmas.

chaconne: a slow, stately dance-with-variations composition form especially popular during the 17th and early 18th centuries.

chanson: French for song; in particular, a style of 14th-16th century French song for voice or voices, often with backing instrumental accompaniment.

chant/plainchant: monophonic music used in Christian liturgical services. It is sung in unison and in a free rhythm, and as a style probably dates from the first century of the Christian era.

concertante: when used to modify another form or genre term, this word suggests a greater than usual amount of concerto-like virtuoso display from one or more of the players.

concerto: (1) ensemble music for voice(s) and instrument(s) (17th century); (2) extended piece of music in which a solo instrument or instruments is contrasted with an orchestral ensemble (post-17th century).

concerto grosso: orchestral form especially popular in the 17th and 18th centuries in which the contrasting lines of a smaller and a larger group of instruments are featured.

credo: third item of the Ordinary of the Mass.

divertimento/divertissement: a style of light, often occasion-specific, instrumental music arranged in several movements; especially popular in the mid to late 18th century.

etude: a study; especially, a piece written for purposes of practicing or displaying technique.

fantas(-ia)(-ie)(-y)/phantasie: especially, an instrumental piece in which conventional form is suspended in favor of the application of imaginative stylizations or improvisation (the term is also applied to several similar concepts).

fugue: contrapuntal form in which a subject theme ("part" or "voice") is introduced and then extended and developed through some number of successive imitations. 7

galliard: a lively court dance of Italian origin, usually in triple time, popular in 16th and 17th centuries.

gigue (jig): a quick, springy dance often used as the concluding movement to 18th century instrumental suites.

gloria: second item of the Ordinary of the Mass.

impromptu: a short instrumental piece of a free, casual nature suggesting improvisation.

incidental music: music composed for the production of a predominantly spoken play.

Lied(er): German for song(s); in particular, a style of 19th century German song distinguished by the setting of texts from the literary tradition and by the elaboration of the instrumental accompaniment.

madrigal: (1) a 14th century Italian style of setting secular verse for two or three unaccompanied voices; (2) a 16th/17th century contrapuntal setting of verse (usually secular) for several equally important voice parts, usually unaccompanied.

magnificat: a setting of the Biblical hymn of the Virgin Mary (as given in St. Luke) for use in Roman Catholic and Anglican services; 14th century to present.

march: instrumental music with a repeated and regular rhythm such as might appropriately accompany a marching group.

masque: an aristocratic 16th-17th century English theater form integrating poetry, dance, music, and elaborate sets.

mass/messe/missa: the principal religious service of the Catholic Church, with musical parts that either vary according to Church calendar (the Proper) or do not (the Ordinary).

mazurka: a moderately fast Polish country dance especially popular in Europe during the 18th and 19th centuries.

microtonal music: music which makes use of intervals smaller than a semitone (a half step).

minuet: a graceful French dance of moderate 3/4 tempo often appearing as a section of extended works (especially dance suites) of the 17th and 18th centuries.

motet: (1) to c1400, a piece with one or more voices, often with different but related sacred or secular texts, singing over a fragment of chant in longer note-values; (2) after 1400, a polyphonic setting of a short sacred text.

nocturne: a moderately slow piece, usually for piano, of dreamy, contemplative character and song-like melody.

ode: cantata-like musical setting of the lyric poetry form so called.

opera: theatrically staged story set to instrumental and vocal music such that most or all of the acted parts are sung; c1600 to present.

operetta: in its modern form (c1850s onward), a light opera containing interludes of spoken dialogue and dance.

oratorio: originally, a setting of an extended religious narrative (and since c1800, nonreligious ones as well) for vocal soloists, chorus, and orchestra, intended for concert or church performance without costumes or stage settings; c1600 to present.

partita: term initially applied as a synonym for "set of variations" (17th century), then as a synonym for "suite" (c1700 to present).

passacaglia: an instrumental dance form similar to the chaconne in which there is continuing repetition of a theme usually played in the bass; originated in Spain and became popular in France and Italy during the Baroque Period.

pavan(e): a quiet, stately court dance (probably of Italian origin) of the 16th and 17th centuries, and remaining popular in the 17th century as an instrumental form.

polka: an energetic Bohemian dance performed in the round in 2/4 time. Originally a peasant dance, but in the mid-19th century it became popular throughout all classes in Europe and America.

polonaise: a stately Polish processional dance in 3/4 time; especially popular as an instrumental form in the 18th and 19th centuries.

prelude: an instrumental section or movement preceding/introducing a larger piece or group of pieces.

quadrille: a lively 19th-century French square dance sometimes incorporating popular tunes of the day.

requiem: generally speaking, a musical composition honoring the dead; more specially (1) the Roman Catholic Mass for the dead; or (2) other commemorative pieces of analogous intent.

rhapsody: term similar to "fantasia" applied to pieces inspired by extroverted romantic notions; 19th and 20th centuries.

romance/romanze: (1) a song with a simple vocal line and a simple accompaniment; especially popular in late 18th/19th century 8

France and Italy; (2) a short instrumental piece with the lyrical character of a vocal romance.

rondo: an instrumental form in which the first or main section is repeated between subsidiary sections and to conclude the piece; usually in lively tempo.

scherzo: term designating lively and usually lighthearted instrumental music; most commonly used to label the fast-tempo movement of a symphony, sonata, etc.

serenade: a light and/or intimate piece of no specific form such as might be played in an open-air evening setting.

sinfonia: term applied in a variety of contexts in different periods; e.g., as a near synonym for "instrumental canzona," "prelude," "overture," and "symphony."

sonata: an extended piece for instrumental soloist (or featured instrument with solo instrumental accompaniment), usually in several movements; in its modern form dating from the early 18th century.

sonatina: a short sonata, or one of modest intent; especially popular during the Classical Period.

song cycle: a group of songs performed in an order establishing a musical continuity related to some underlying (conceptual) theme.

Stabat Mater: a sequence in the Roman Catholic liturgy regarding the crucifixion, and used in several Divine offices.

suite: a set of unrelated and usually short instrumental pieces, movements or sections played as a group, and usually in a specific order.

symphonic poem/tone poem: a descriptive orchestral piece in which the music conveys a scene or relates a story; c1850 to present

symphony: an extended piece for full orchestra, usually serious in nature and in several movements; early 18th century to present.

tango: Argentinian dance danced by couples and marked by strong syncopation, dotted rhythmic figures, and a 2/4 time signature.

Te Deum: (from the Latin, "We praise Thee, O God") lengthy hymn of praise to God in the Roman Catholic, Anglican, and other Christian liturgies.

toccata: a piece for keyboard, usually technically demanding, intended as a display for virtuosity.

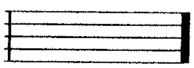
trio sonata: a chamber music form for two featured instruments and continuo accompaniment; especially popular in the 17th and 18th centuries.

variations: composition form in which variously modified re-statements of an initially introduced theme are presented in sequence, one after another.

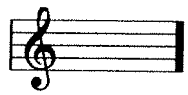
waltz/valse: a popular ballroom dance in 3/4 time dating from c1800.

Note Names

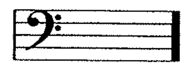
The musical language in the western world is represented by numerous symbols that appear on, over, and under five lines and four spaces that we call a staff. The first such symbol that appears is a clef that identifies the names of notes on, above and below the staff. Examples of the note names and ways to remember them are given below along with a practice sheet.



Staff



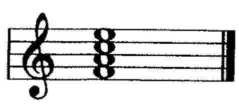
Treble (G) Clef



Bass (F) Clef

C D E F G A B C D E F G A B C

C B A G F E D C B A G F E D C



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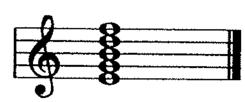
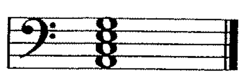
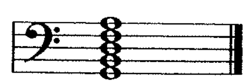


Every Good Boy Does Fine

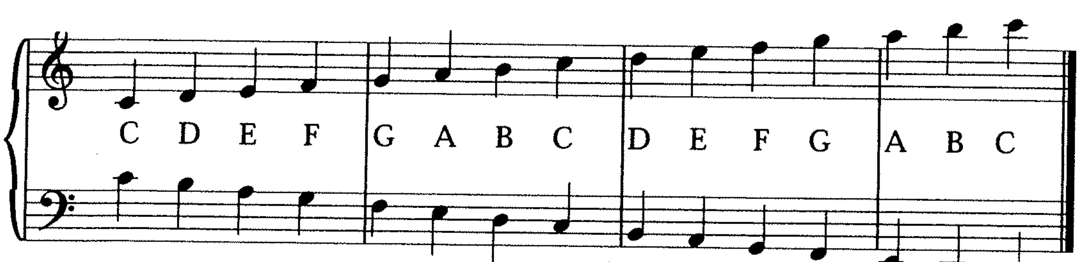


All Cows Eat Grass



Good Boys Do Fine Always

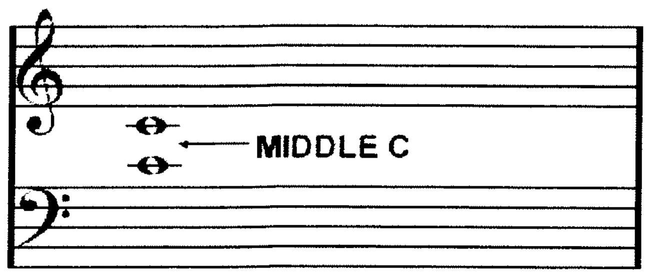
Grand Staff (notes and names in both Treble and Bass Clefs)



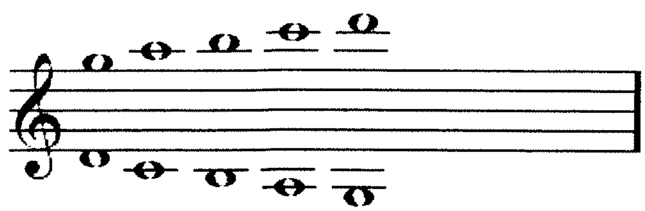
C B A G F E D C B A G F E D C

MI: LIBRARY: THEORY: BASICS: GREAT STAFF

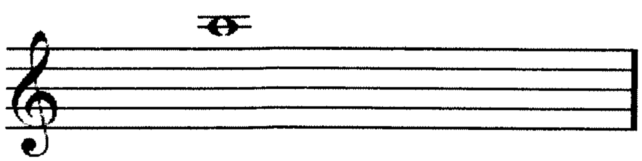
The **great staff** (or grand staff) is a double staff with both treble and bass clefs. All the most common pitches are on this staff. Middle C is right between the two.



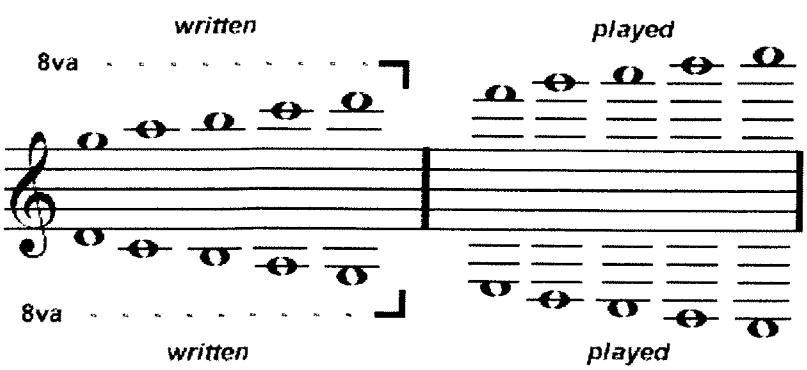
For notes above or below the range of the 5 line staff, small segments are added in both directions called **ledger lines**. They are spaced with the same distance as the 5 lines of the staff, and wide enough to pass each side of the note.



Each note beyond the staff is on or above the leger line, no line is used beyond the note:



A way to specify notes above the range of a staff without changing the clef, is the **octave sign (8va)**, this indicates that the notes in the bracket are to be played 1 octave higher or lower. An octave is the pitch with the same name eight notes in either direction. Another octave sign **(15va)** indicates to play 2 octaves different; its is very rarely used.

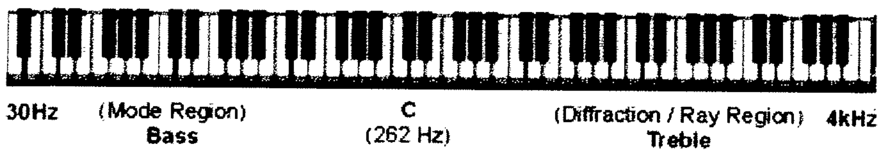


11

The Musical Frequency Range

The piano keyboard represents the musical frequency range. We have middle "C" which separates the musical bass from treble. The piano keyboard spans frequencies from 30Hz to 4,000 Hz.

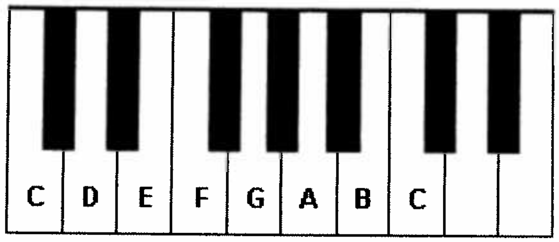
Overtones of certain instruments can produce sounds as high as 20,000 Hz (20 kHz)



The Notes

Before we learn how to write the notes on the staff, let's check over their name and order.

Our music system has seven notes. The order of these notes is C, D, E, F, G, A, and B. These notes correspond to the white keys of the piano: CENTER OF KEYBOARD



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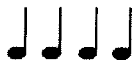
MI: LIBRARY: THEORY: BASICS: NOTES

Notes are the symbols that tell the length or duration of a sound. Starting at the whole note, the others decline by half the previous note.

Whole note 

Half notes 

Quarter notes 

Eighth notes 

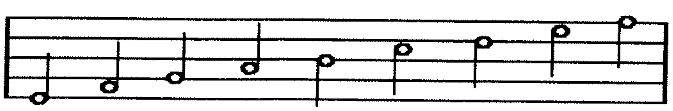
Sixteenth notes 

32nd notes  (2x)

64th notes  (4x)

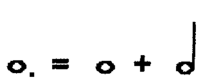
STEMS

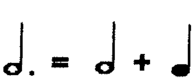
As you can see all the notes (except the whole notes) have a line extending from the notes round bottoms. These are called **stems.** Stems are drawn down on the left if the note is above the middle line of the staff, and up to the right if it is below. For those on the middle, the stem can go either way, but down is more usual.



DOTS

A dot after a note adds one half to the value of the note.





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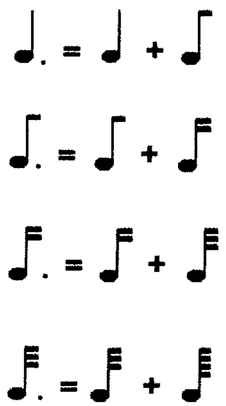
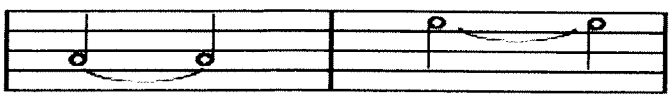


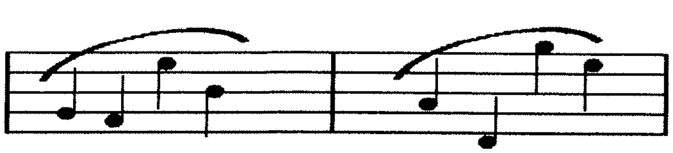
TIES & SLURS

A **tie** is a curved line between two notes with the same pitch. Maintain that pitch for the duration of both notes.



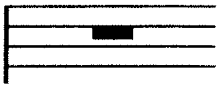
A **tie** is needed if a note is held across multiple measures or beyond a bar line.

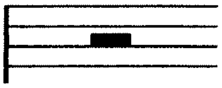
A curved line above or below a group of different notes, is called a **slur**. It tells to smoothly play all notes with no breaks between.



MI: LIBRARY: THEORY: BASICS: RESTS

Rests indicate silence. Each note have its corresponding rest sign.

 Whole note rest

 Half note rest

 Quarter note rest

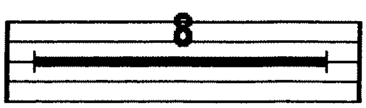
 Eighth note rest

 16th note rest

 32nd note rest

 64th note rest

In ensemble music, parts may have several measures of rest at a time. A long rest sign, with a number above, indicates the number of measures of rest. The rest sign is drawn through the center line:

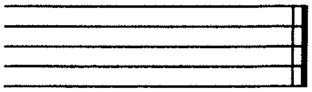


8 measure rest

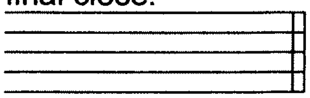
16

MI: LIBRARY: THEORY: BASICS: DOUBLE BARS

A double bar is placed at the end of a work. It consists of a narrow bar line and a wider bar line:

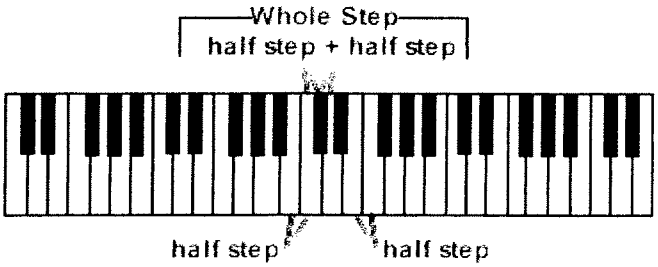


A double bar with *two narrow bar lines* indicates the end of part of a work or section, but no the final close:



MI: LIBRARY: THEORY: BASICS: HALF/WHOLE STEPS

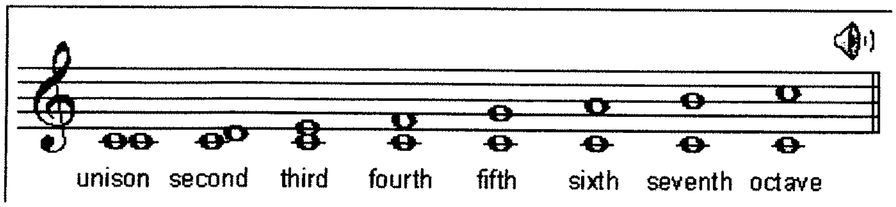
In most music, the smallest interval, or distance, between two tones is a half step. Two half steps combined make a whole step. Take a look at the piano keyboard, notice a black key between C and D. The distance from C up to that black key is a half step. From the black key to D is a second half step. The two half steps combined equal a whole step. The nearest key, black or white, above or below any other key is a half step. So, the next white key above B or E, or below C or F, is a half step.



18

Numerical size of intervals

By counting the number of notes in an interval we obtain its numerical size. The first and last note must be counted. For example, from C to E we have a third (C-1, D-2, E-3). In the next figure you can see the relationship between the number of notes and the numerical size of intervals:



Yet, not all intervals of the same numerical classification are of the same size. That is why we need to specify the quality by finding the exact number of whole and half steps in the interval.

Mathematics Relation of Intervals

The A above middle C normally has a frequency of 440 cycles per second, or Hertz. This means that it vibrates 440 times per second. An A, one octave higher has a frequency of 880 Hz., exactly twice as many vibrations per second. The mathematical expression of this relation is 880:440 or 2:1. The following table shows the mathematical relationship of several intervals, ordered from consonant to dissonant.

Relation	Interval
2:1	Octave
3:2	Fifth
4:3	Fourth
5:4	Major Third
6:5	Minor Third
9:8	Major Second
16:15	Minor Second

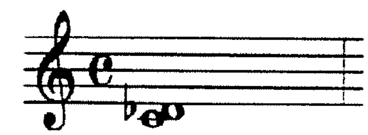
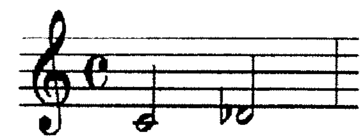
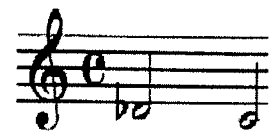
LISTEN TO INTERVALS

For each interval, click on the notation images to hear its sound.
Listen to the interval with the pitches played together, ascending, and descending.

Association with a familiar tune can be helpful for memorizing the sound of an interval.
The tunes listed just below each interval group begin with that interval.

(Any suggestions for other tunes?
If so, please take a minute to send your suggestions to musicalintervalstutor@yahoo.com or via the Guest Book!)

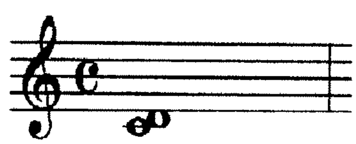
Minor 2nd [half step]

Click here to listen to more minor 2nds.

Fur Elise (Beethoven) ~ Pink Panther (movie theme)
Jaws movie theme (thanks InCuBuSRoXs88!)

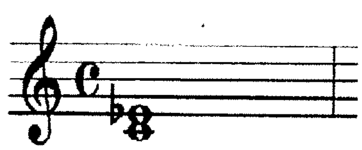
Major 2nd [whole step]



Click here to listen to more major 2nds.

Pop Goes the Weasel ~ Happy Birthday

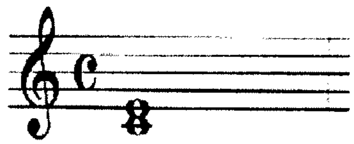
Minor 3rd



Click here to listen to more minor 3rds.

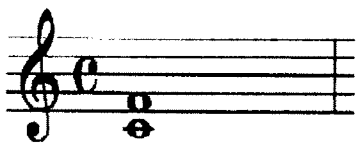
This Old Man ~ Greensleeves (or What Child is This - thanks Roy R!) ~ O Canada (thanks Heidi!)

21

Major 3rd			

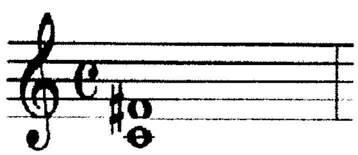
Click here to listen to more major3rds.

Swing Low Sweet Chariot ~ Kum Ba Ya

Perfect 4th			

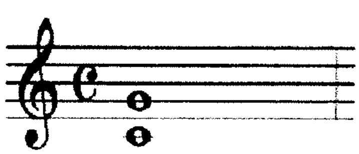
Click here to listen to more perfect 4ths.

Home on the Range ~ Born Free (movie theme) ~ Here Comes the Bride ~ Amazing Grace (thanks Thomas E!)

Augmented 4th			

Click here to listen to more augmented 4ths.

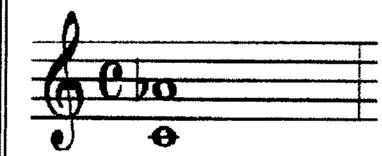
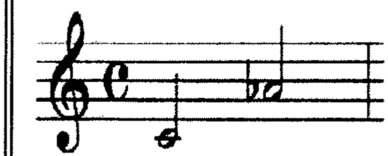
Maria (West Side Story)

Perfect 5th			

Click here to listen to more perfect 5ths.

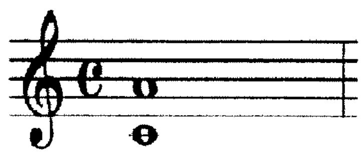
The Erie Canal ~ Twinkle Twinkle Little Star

Minor 6th			22

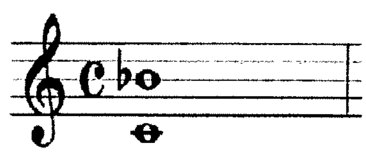
Click here to listen to more minor 6ths.

Love Story (movie theme)

Major 6th			

Click here to listen to more major 6ths.

My Bonnie Lies Over the Ocean ~ Surfer Girl (Beach Boys) ~ It Came Upon a Midnight Clear (Christmas) ~ NBC Theme (thanks ameska01 and Hobo)

Minor 7th			

Click here to listen to more minor 7ths.

Somewhere (West Side Story)

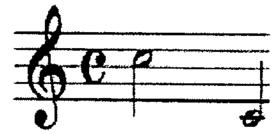
Major 7th			

Click here to listen to more major 7ths.

Perfect Octave			

23





Click here to listen to more octaves.

Somewhere Over the Rainbow (The Wizard of Oz)

Musical Intervals Tutor Home

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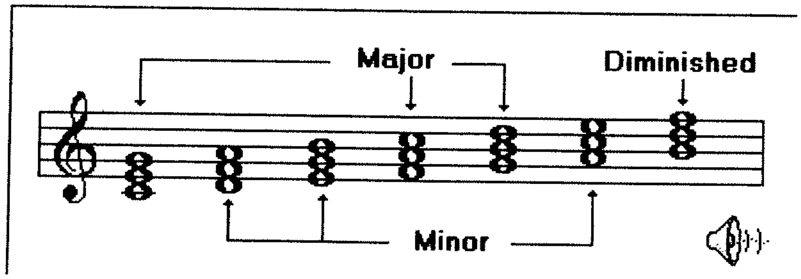
Triads in Major Scales

The following example show triads that may be formed by using the notes of a major scale:



In all major scales, triads that are formed on degrees I, IV, and V are major. Those formed on degrees II, III, and VI are minor; the triad formed on degree VII is diminished.

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Consonance and Dissonance

Intervals can be classified as **consonant** or **dissonant** according to the complexity of the mathematical relation between the notes pitches.

Although this concept has changed during musical history and even today not all theoreticians agree, we can offer the following classification:

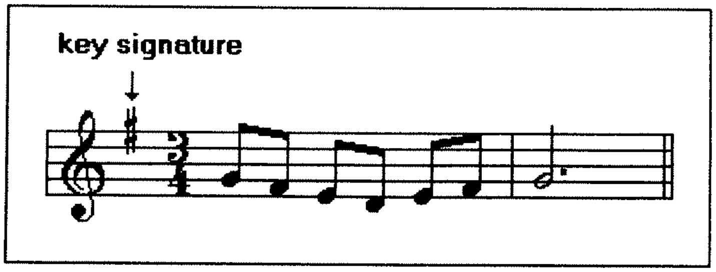
Consonant	Dissonance
Unison	Seconds
Major and minor third	Sevenths
Perfect fourth (considered a dissonance in harmony and counterpoint)	Augmented fourth
	Diminished fifth
Perfect fifth	
Major and minor sixth	
Perfect octaves	

26

Key Signatures

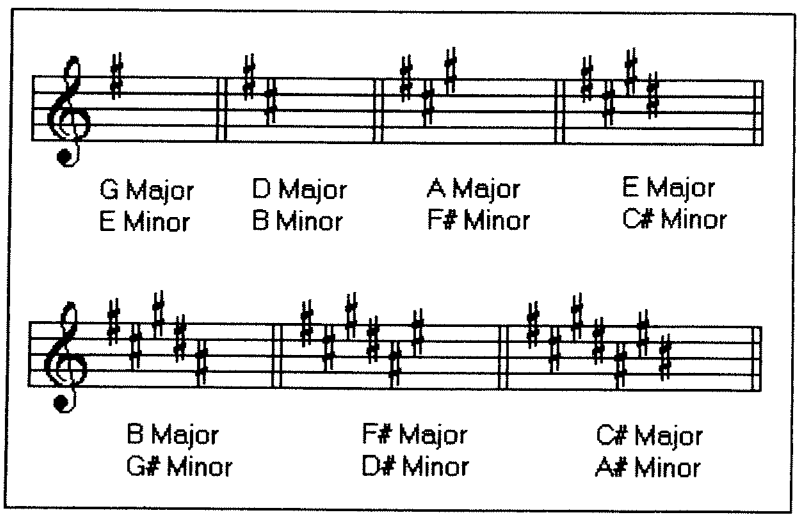
Major and natural minor scales built on C and A respectively do not contain any altered note. In order to build these scales starting from any other note, it is necessary to alter one or more notes. For instance, in the scale of G major, note F is sharp. If you wished to write a melody in G major, you would need to alter all F notes. Key signatures are used to avoid writing so many accidentals.

Key signatures are placed at the beginning of each staff, between the clef and the meter signature:



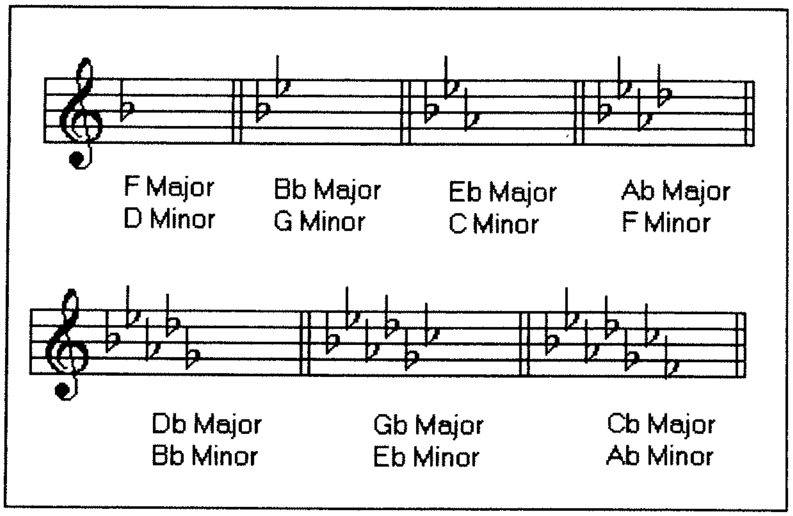
In the former melodic fragment, all F are sharp. Therefore, if you want to write a natural F, it should be preceded by a natural.

Scales with sharps in their key signatures are the following:



27

Scales with flats in their key signatures are the following:



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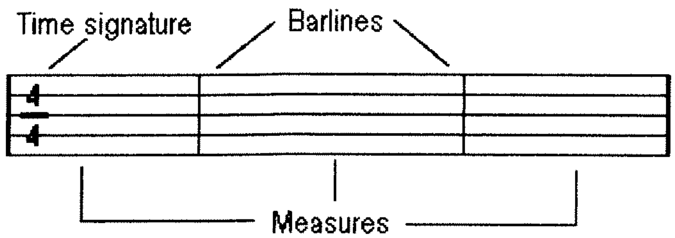
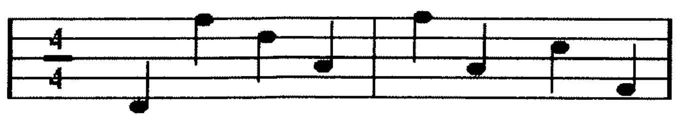
MI: LIBRARY: THEORY: BASICS: METERS

The meter signature, or time signature, is at the beginning of a piece of music. It indicates the pattern of accented and unaccented beats. The top number indicates the number of beats in the pattern, and the bottom number indicates the note value of the beat. These patterns are grouped in bars, called measures, in between bar lines.

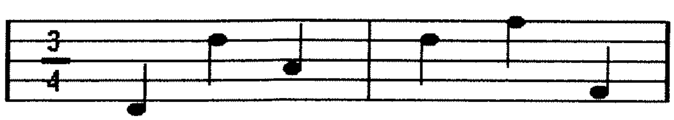


Simple Meters

4 beats in the bar
4 quarter note gets one beat



3 beats in the bar
4 quarter note gets one beat



2 beats in the bar
4 quarter note gets one beat

6 beats in the bar
8 eight note gets one beat

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$\frac{3}{8}$ beats in the bar
eight note gets one beat

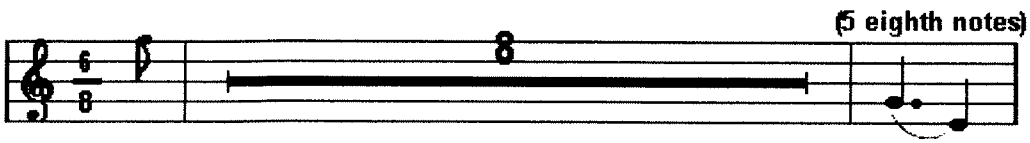
Try to find some on your own, most are real, but rare, such as $\frac{5}{4}$. This can however be found in Dave Brubecks jazz piece, "Take Five".

Other more common meters include: $\frac{2}{8}$, $\frac{3}{2}$, $\frac{4}{2}$, etc.

MI: LIBRARY: THEORY: BASICS: ANACRUSIS

Compositions don't always begin on the first beat of the first measure. One or several notes can occur beforehand. This note is called an anacrusis. (Also known as an 'upbeat' or 'pick-up note'.)

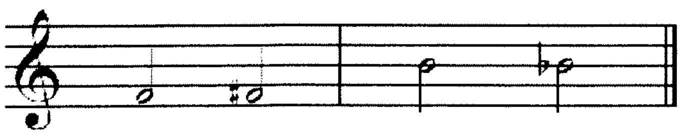
Normally, the number of beats or the fraction of a beat used in the anacrusis is subtracted from the last measure of the work.



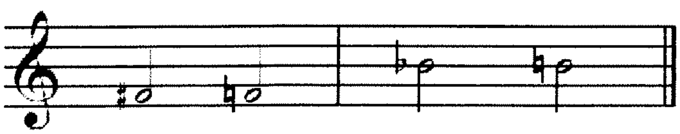
MI: LIBRARY: THEORY: BASICS: ACCIDENTALS

Accidentals are symbols that indicate the raising or lowering of the pitch of a tone. Accidentals are always placed in front of the note it affects.

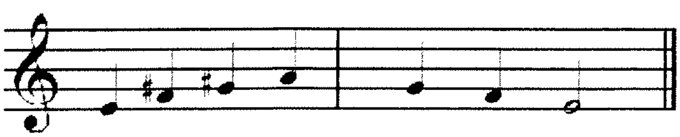
A sharp (♯) raises the pitch of a tone by a half step. A flat (♭) lowers the pitch of a tone by a half step.



A natural (♮) is used to cancel a sharp or flat within a measure.



Except for the accidentals in the key signature, a bar line cancels all accidentals in a previous measure.



Except for the accidentals in the key signature, an accidental affects a note only in the measure in which it appears, and only that one line or space. Exp. the second note in this measure is F natural.

A double flat (𝄫) lowers the pitch of a tone by two half steps (a whole step).

A double sharp (x) raises the pitch of a tone by two half steps (a whole step).

To cancel a double sharp or flat within a measure, use a double natural sign. (♮♮)

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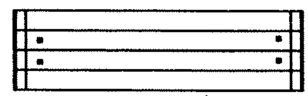
To cancel part of a double sharp or flat, use a combination of the natural sign and the sharp or flat signs.

MI: LIBRARY: THEORY: BASICS: REPEATS

There are several kinds of repeat signs used to direct the performer to skip back or forward through a piece of music. These signs are used to avoid writing out long repeated passages.

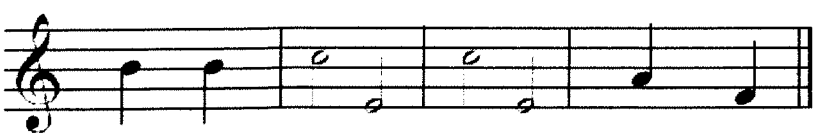
- D.C. (*da capo*) repeat from the beginning
- D.S. (*dal segno*) repeat from the sign (𝄋)
- *fine* the end
- D.C. al fine (*da capo al fine*) repeat from the beginning to the end
- D.S. al fine (*dal segno al fine*) repeat from the sign (𝄋) to the end coda a section at the end of a work
- D.C. al coda repeat from the beginning to the coda sign (𝄌) then skip to the coda
- D.S. al coda repeat from the sign (𝄋) to the coda sign (𝄌) and then skip to the coda

Sometimes the double bar with two dots is used in pars to indicate a repeat. the measures within the repeat signs are played twice. The repeat signs always have two dots on the inside, facing measures to be repeated. If the repeat is to the beginning of the work, a sign at the beginning is not required.

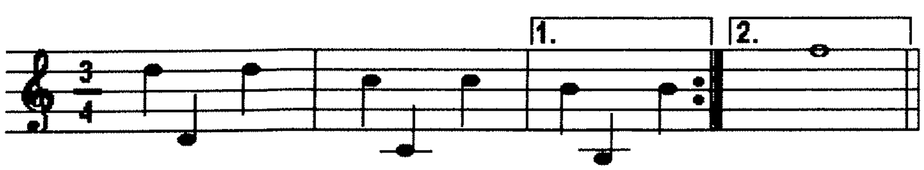


repeat signs

is played:



Sometimes, when music repeats, first and second endings are used in order to save space. The first ending, which has a repeat sign, is played only the first time through. The second time, the first ending is skipped over and the second is played.

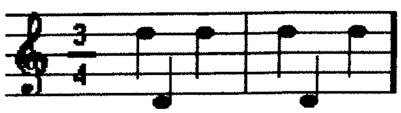


is played

34

Another common repeat sign (𝄎), is a sign indicating to repeat a phrase of 1 - 2 measures. In patterns that are repeated over and over, this method is a "time-saver". A one-measure repeat is represented by the sign placed inside one measure.

is played



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Tempo Terms

Grave - Very Slow

Largo, Lento - Slow

Larghetto - A little faster than Largo

Adagio - Moderately Slow

Andante - "Walking" Tempo 70 - 90

Andantino - A little faster than Andante

Allegretto - A little slower than Allegro

Allegro - Fast

Vivace - Lively

Presto - Very Fast

Prestissimo - Very Very Fast

Moderato - Moderate(ly)

Molto - Very

Accel., Accelerando - Gradually becoming faster

Rit., Ritardando - Gradually becoming slower

Articulation

Summary: An introduction to basic musical articulation markings.
Objectives:

The word **articulation** in general refers to how the pieces of something are joined together; for example, how bones are connected to make a skeleton or syllables are connected to make a word. Articulation depends on what is happening at the beginning and end of each segment, as well as in between the segments.

In music, the segments are the individual notes of a line in the music. The line may be in the MELODY, the BASS, or the HARMONY. It may be sung or might be played by any instrument: oboe or viola, harp or electric guitar or bells. In any case, it is a string of notes that follow one after the other and that belong together in the music, and the **articulation** of the notes is what happens in between and at the beginnings and ends of the notes.

I will not describe here how each articulation is done, because that depends too much on the particular instrument that is making the music. In other words, the technique that a violin player uses to slur notes will be completely different from the technique used by a trumpet player, and a pianist and a vocalist will do different things to make a melody sound legato. If you are wondering how to play slurs on your guitar or staccato on your clarinet, ask your music teacher or band director. What you will find here is a short list of the most common articulations: their names, what they look like when notated, and a vague description of each articulation. The desciptions have to be vcague, because articulation, besides depending on the instrument, also depends on the style of the music. Exactly how much space there should be between staccato eighth notes, for example, depends on how fast the music is and whether you're playing Rossini or Sousa. This is one of those cases when a sound is worth a thousand words, so I hope to include some audio demonstrations here soon.

Common Articulations

- *staccato* - **Staccato** notes are short, with plenty of space between them. Please note that this doesn't mean that the tempo or rhythm goes any faster. The tempo and rhythm are still as marked; the staccato notes sound shorter than written only because of the space between them.
- *marcato* - Marcato means "marked" in the sense of "stressed" or "noticeable". Notes marked **marcato** have enough of an accent and/or enough space between them to make each note seem stressed or set apart. They are usually longer than staccato but shorter than legato.
- *legato* - Legato is the opposite of staccato. The notes are very connected; there is no space between the notes at all. There is, however, still some sort of articulation that causes a slight but definite break between the notes (for example, the violin player's bow changes direction, the guitar player plucks the string again, or the wind player uses the tongue to interrupt the stream of air).
- *slur* - When notes are slurred, only the first note under each slur marking has a definite articulation at the beginning. The rest of the notes are played (or sung) so connectedly that there is no break between the notes.
- *tie* - A tie looks like a slur, but it is between two notes that are the same pitch. *A tie is not really* 38

an articulation marking. It is included here because it looks like one, which can cause confusion for beginners. When notes are tied together, they are played as if they are one single note that is the length of all the notes that are tied together. The tie is used to make music easier to read.

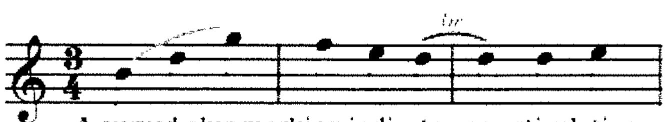
- *Accents* - An ACCENT is usually performed by making the accented note, or the beginning of the note, louder than the rest of the music. Although this is mostly a quick change in DYNAMICS, it usually affects the articulation of the note, too. The extra loudness of the note usually requires a stronger, more definite attack at the beginning of the accented note, and it is emphasized by putting some space before and after the accented notes. The effect of a lot of accented notes in a row often sounds marcato. Some accents may even be played by using articulation alone (not dynamics) to emphasize the note.
- *No articulation marked* - Plenty of music has no articulation marks at all, or marks on only a few notes. Often, such music calls for notes that are a little more separate or defined than legato, but still nowhere as short as staccato. But it is really up to the performer to know what is considered proper for a particular piece. For example, most ballads are sung legato, and most marches are played fairly staccato or marcato whether they are marked that way or not. And singing or playing a phrase with musicianship often requires knowing which notes of the phrase should be legato and which should be more separate.

Articulation Markings

"Staccato" may be written into the part
or marked with dots above or below the notes.
These staccato quarter notes would sound approximately
like eighth notes and eighth rests:

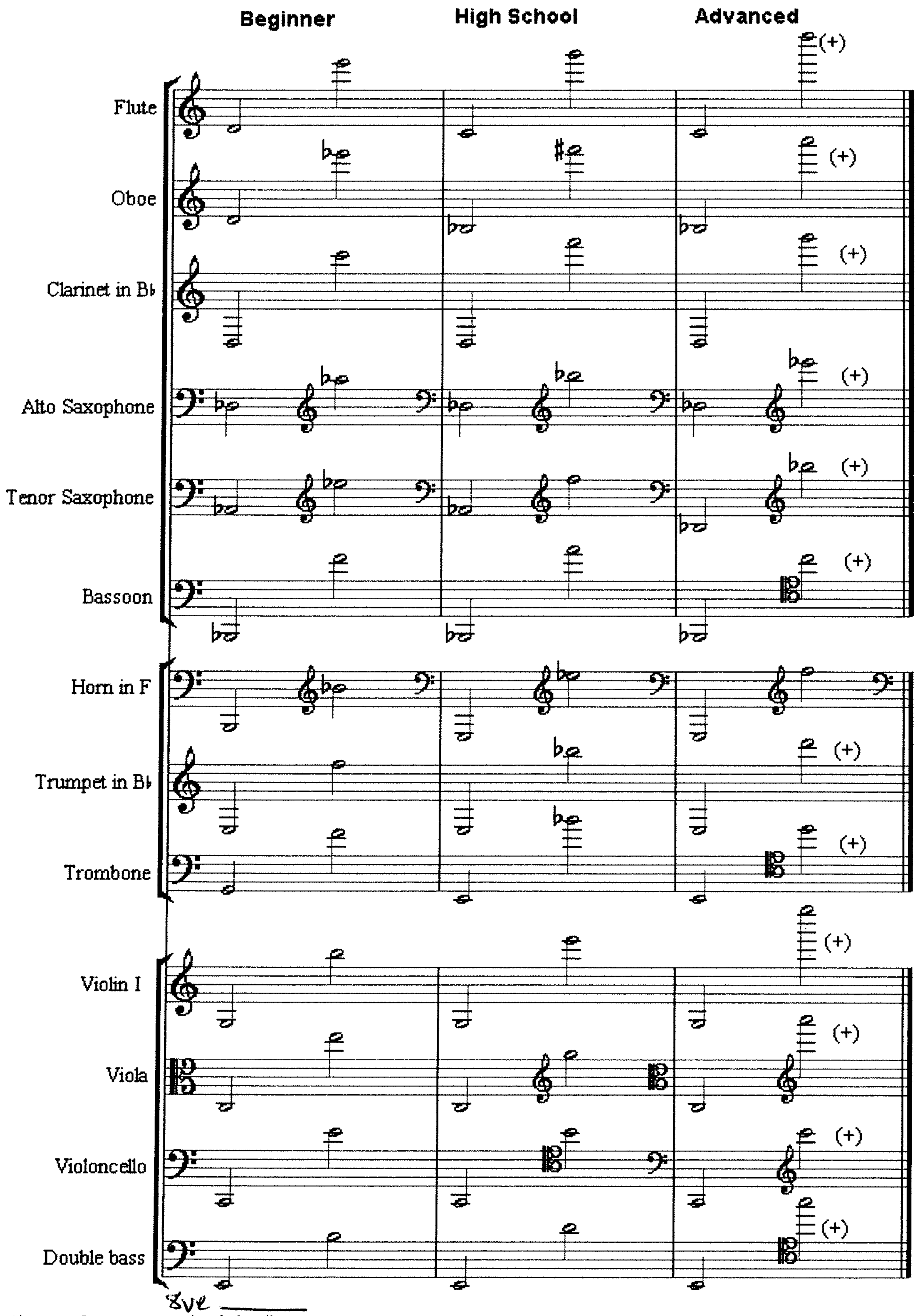
"Legato" may be written into the part,
or marked with long lines above or below the notes.

If a composer wants something in between legato
and staccato, the notes may be "marcato",
or may be marked with various combinations of
dots, lines, slurs, and accents, depending on
what exactly is the effect wanted.

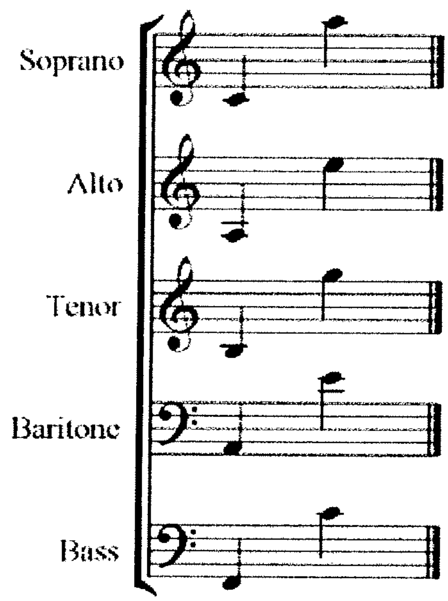


A curved slur marking indicates no articulation
- no break in the sound - between the notes at all.
A tie is used between two notes of the same pitch.
Since there is no articulation between them,
they sound like a single note. The tied quarters here
would sound exactly like a half note.

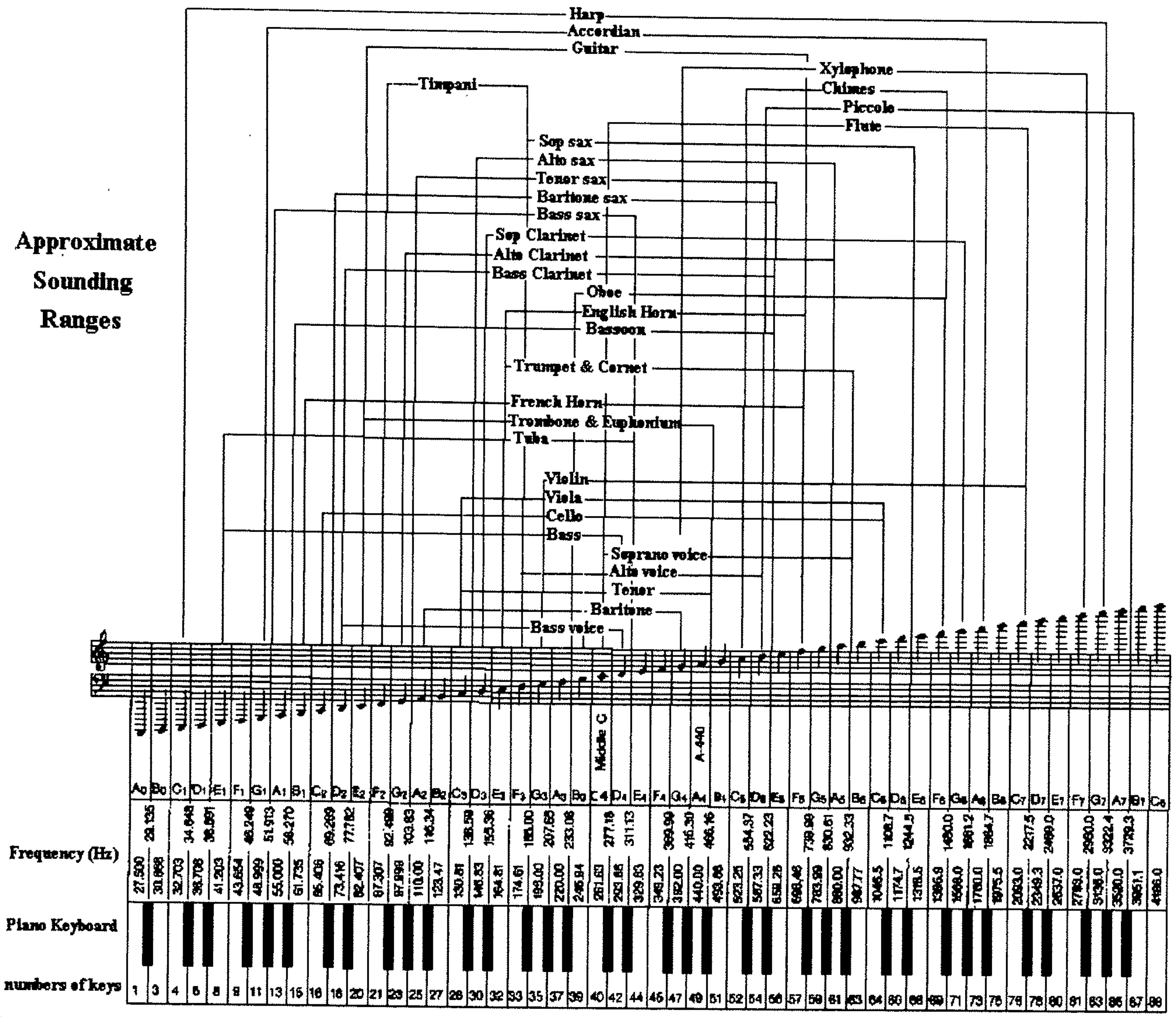
40


Beginner
High School
Advanced
Flute
Oboe
Clarinet in B♭
Alto Saxophone
Tenor Saxophone
Bassoon
Horn in F
Trumpet in B♭
Trombone
Violin I
Viola
Violoncello
Double bass
(+)
8ve

Voice Ranges for singers



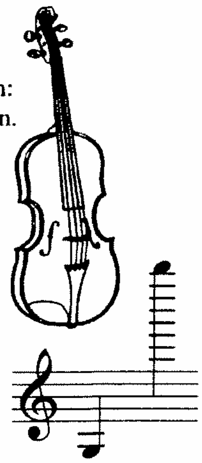
Approximate
Sounding
Ranges



The String Family

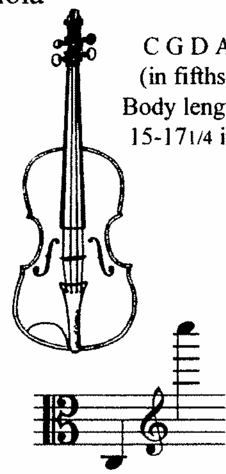
Violin

G D A E
(in fifths)
Body length:
approx. 14 in.



Viola

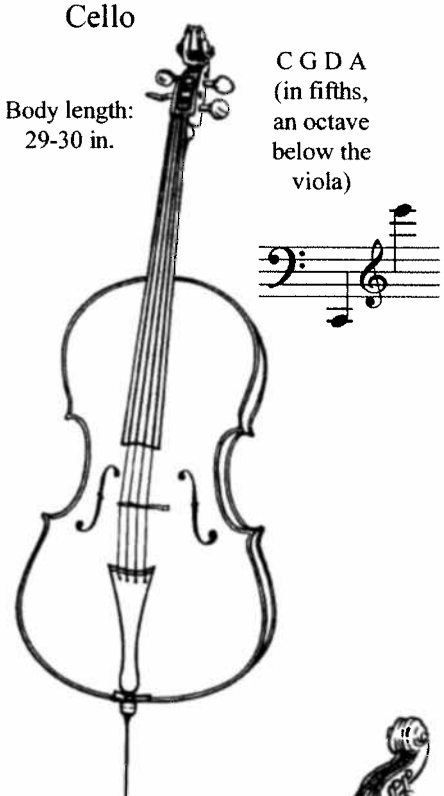
C G D A
(in fifths)
Body length:
15-17 1/4 in.



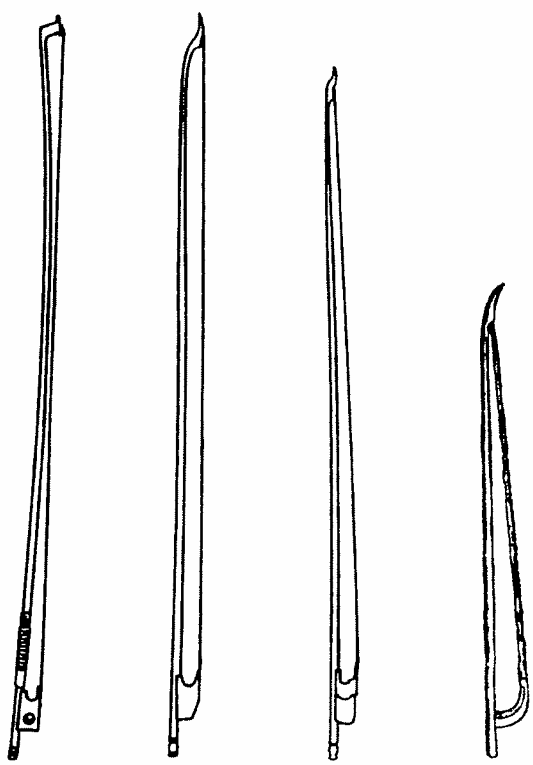
Cello

Body length:
29-30 in.

C G D A
(in fifths,
an octave
below the
viola)



Violin Bows



Tourte
ca. 1800

Thomas Smith
1760-1770

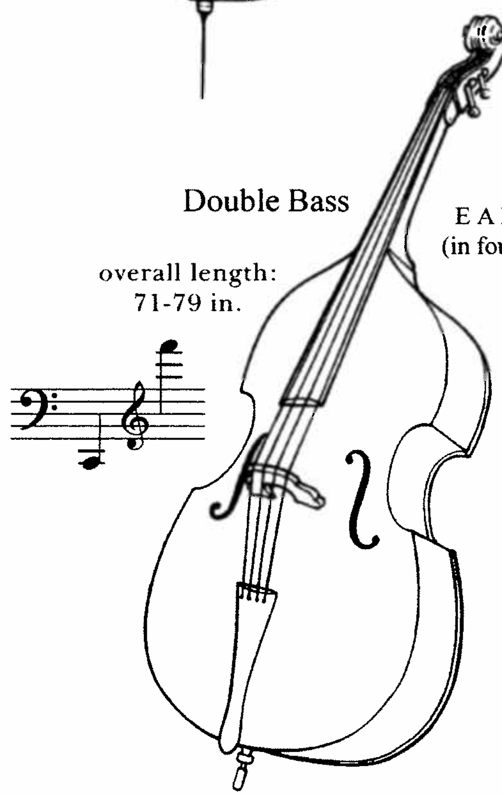
Anonymous
1694

Marin Mersenne
1636-1637

Double Bass

E A D G
(in fourths)

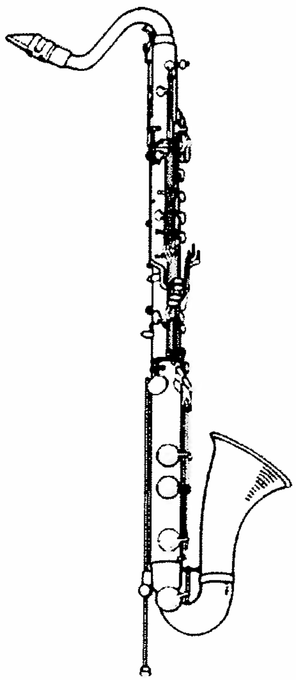
overall length:
71-79 in.



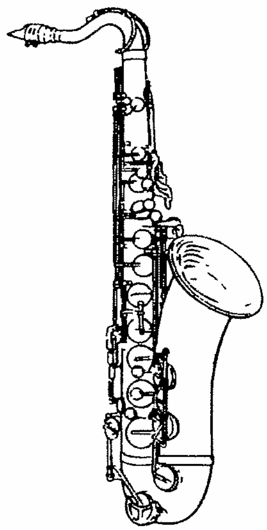
Reed Instruments of the Orchestra

Single Reed Instruments

Bass Clarinet

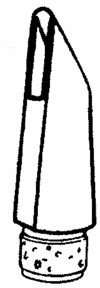


Saxophone

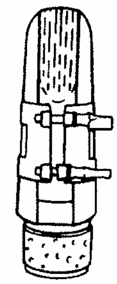


Clarinet

Clarinet mouthpiece without reed

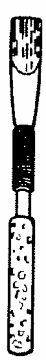


Clarinet mouthpiece with reed



Double Reed Instruments

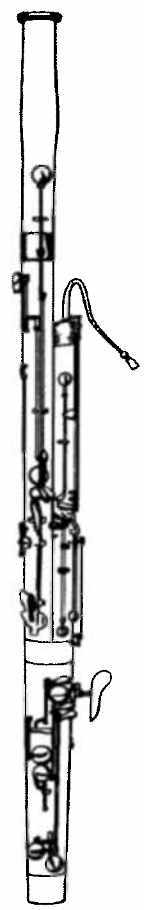
Bassoon Reed



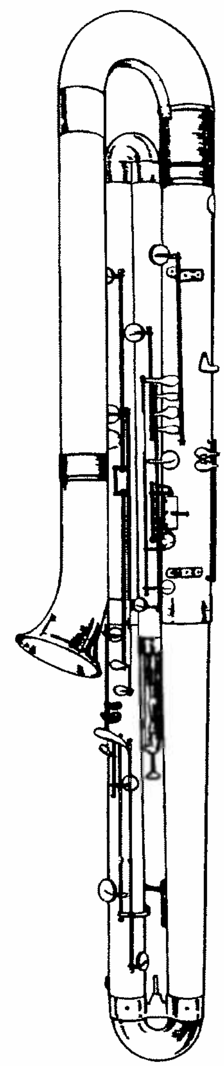
Oboe Reed

Oboe

English horn

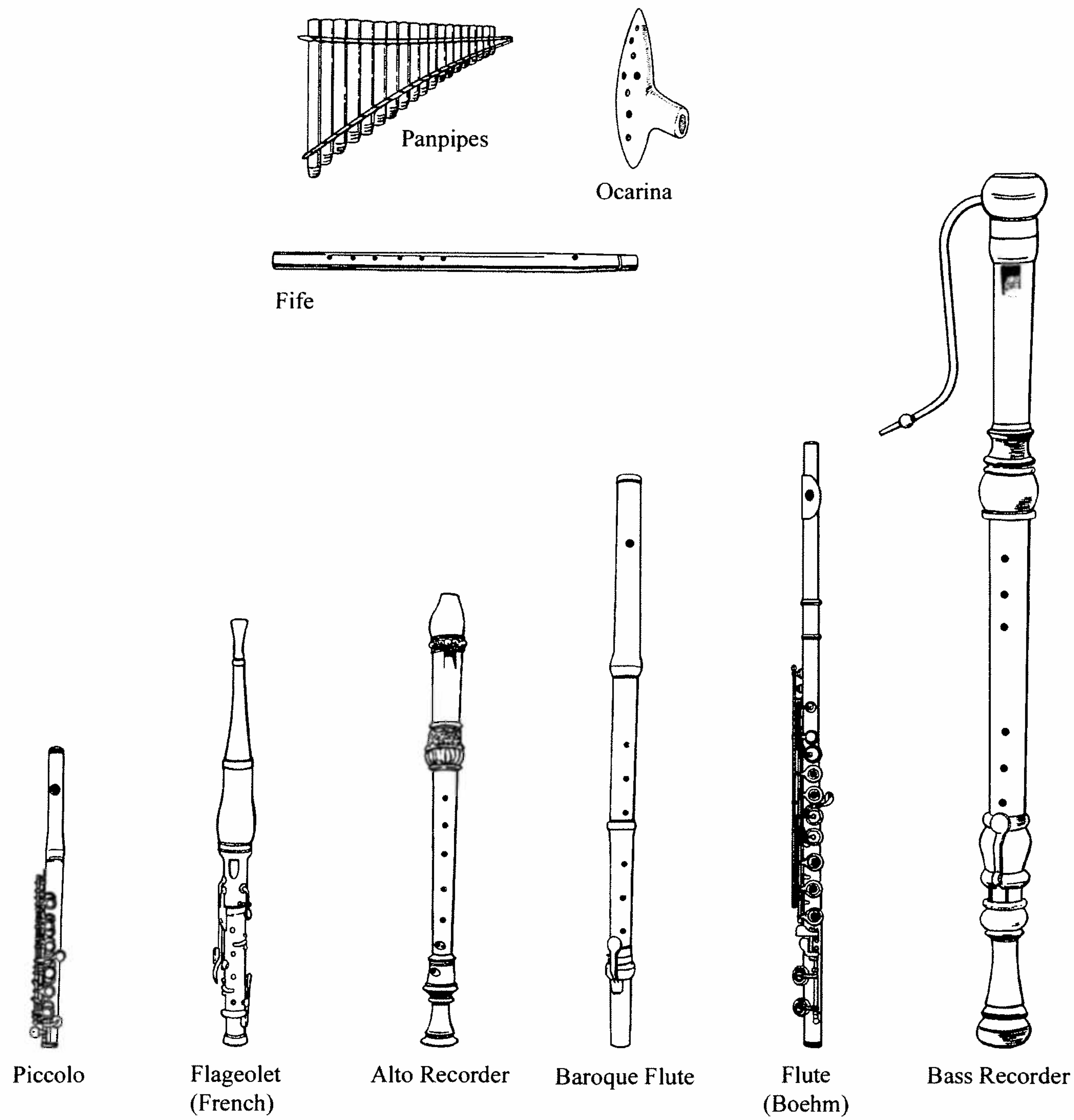


Bassoon



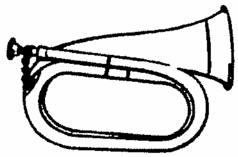
Contrabassoon

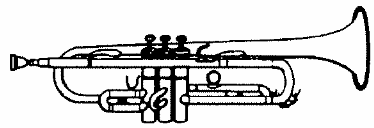
Members of the Flute Family

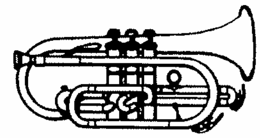


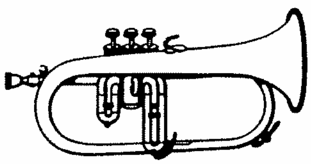
BRASS INSTRUMENTS

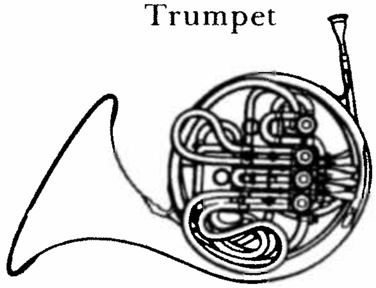
A family of tubular wind instruments made of brass
and sounded by the buzzing of the player's lips.

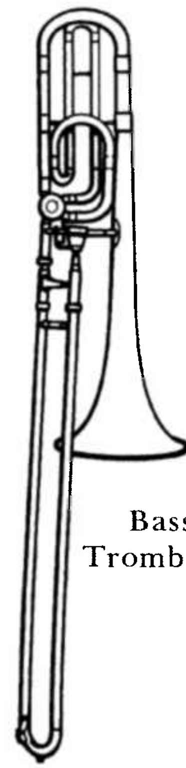

Bugle

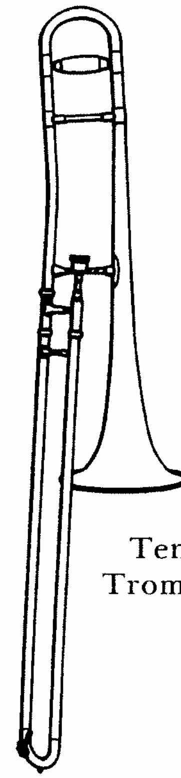

Trumpet


Cornet

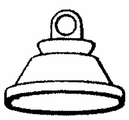

Flugelhorn


French horn

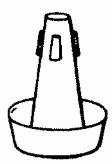

Bass Trombone


Tenor Trombone

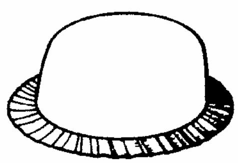
BRASS INSTRUMENT MUTES

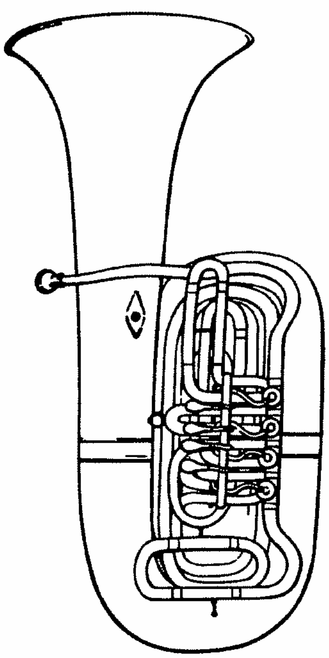

Plunger

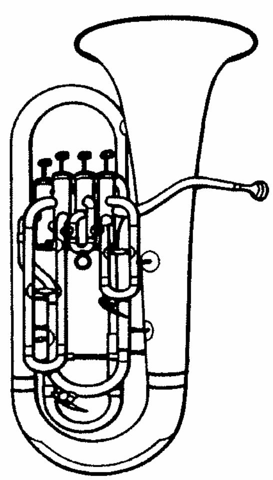

Harmon or wow-wow

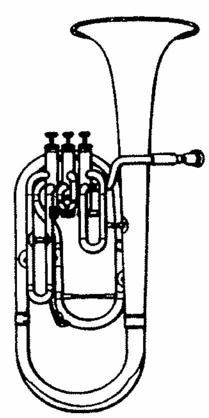

Cup


Straight

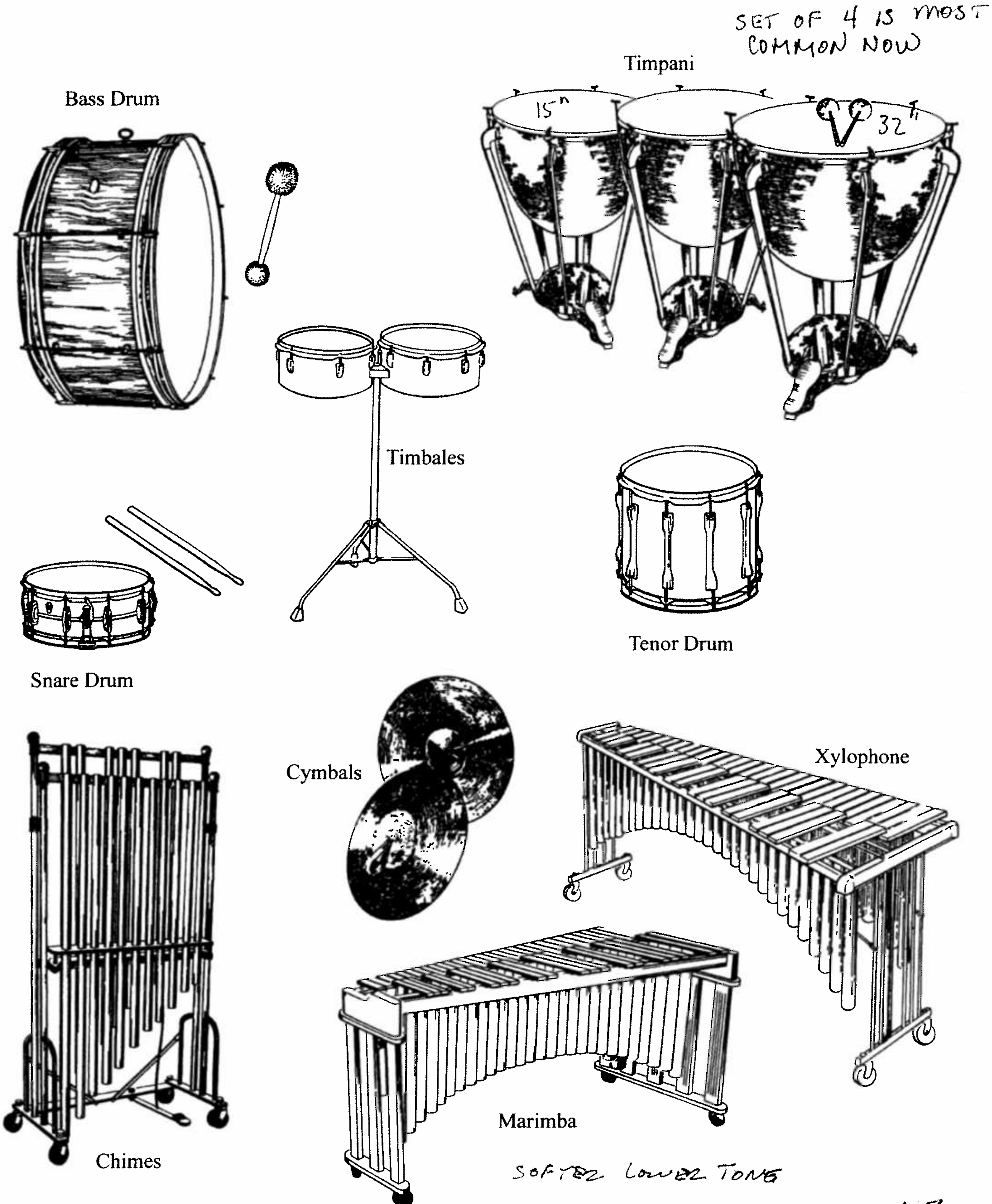

Hat


Tuba

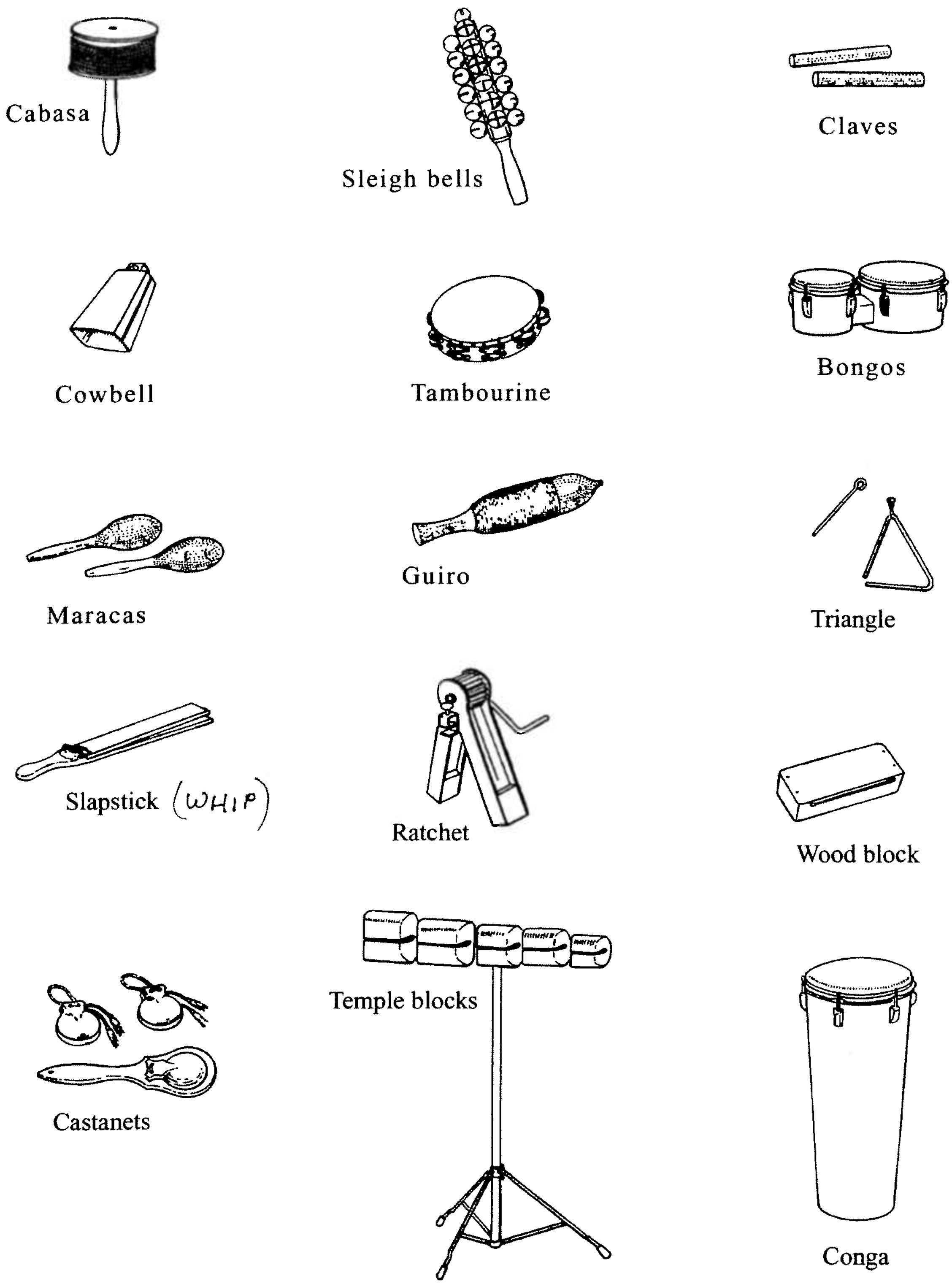

Euphonium


Alto horn

Large Percussion Instruments of the Orchestra



Small Percussion Instruments of the Orchestra



Seating Your Choir

by
Michael Dean
SFA Assistant Director of Choral Activities

There are thousands of ways to seat your choir but very few principles to follow. The goal is to allow your choir to sound their best to the audience. For that to happen each singer needs to be seated next the other singers that wil allow them to sound their best.

1. Weaker singers need to sit with others who sing their part.

2. Stronger singers need to hear other parts to help them balance and tune.

3. Sopranos usually benefit from sitting near the basses. This helps intonation.

4. Everyone benefits from listening to those around them.

There are two basic seating plans with one variation.		
Block Formation B | T S | A	Mixed Formation BSAT | BSAT SATB | ATSB	Mixed-Block Formation BSAT | BSAT BSAT | BSAT
• Improves awareness of section sound • Builds confidence • Allows for fluid changes within section	• Improves ensemble intonation • Requires stronger singers • Improves blend of stronger voices	• Blends the strengths and weaknesses of the other two formations • It is infinitely variable

Start with the block formation. It is the best way to become familiar with your singers and creates the best sense o unity and comfort for the singers. It is also the easiest way to learn new music.

When you and they are ready, experiment with another arrangement according to the strengths of your choir and the music you are singing. Let that dictate your choice and don't be surprised by a dramatic change in sound with some minor changes in seating.

Choral seating : mixed or by voice section?
Placement des choristes par voix ou mélangés

Here are some of my thoughts on choral seating. I base this on my 20 plus years as a choral director and my background of experience within the Lutheran choral tradition as presented by the St. Olaf Choir, Concordia Choir, Luther College Choir, Augsburg Choir, Dale Warland Singers, Lutheran National Choir, etc. It is balanced by my experience, professionally, as a singer in opera; my many years as a producer, conductor, stage director and music director in opera; and over 40 years as a successful studio voice teacher.

The placement of voices in a choir to obtain a blend of choral tone is, or was, a very common concern with choral groups in the United States until recently. It now appears that most choral directors prefer to arrange their groups in a mixed section arrangement, that is, in mixed quartets or some similar "shotgun" seating. The effect of this mixed seating is to create the illusion of a choral blend where little, if any, choral blend really exists.

May I use an analogy. If you observes closely a Seurat pointillism painting you will see that to create the color green, Seurat has placed a series of blue and yellow dots. Viewed from a distance the eye mixes these two colors together to obtain green. However, the two colors were not blended together but only mixed by the eye. If you study a Rembrandt painting you will see colors that have been blended prior to their being placed on the canvas. If you find the similar shade of green in the Rembrandt as in the Seurat, you will notice a large difference. The Rembrandt color is a blend, the Seurat is a mixture that gives the illusion of a blend.

A choral group in mixed formation cannot create a blend, only a mixture. Differences in vowel color, pitch, and even volume will be minimized by this mixed formation. The listener's ear will receive a varied series of signals which the listener must mix together to achieve the illusion of a blend.

A choral group standing in sections by voice part will find that vowel color, pitch and volume differences tend to be emphasized and each member of the section must accommodate to a defined, tonal, pitch and volume goal for the section. This requires compromise of tonal sound from each singer. The amount of compromise can be somewhat minimized by careful placement of the individual singer within the section giving consideration to the ability of each singer to blend with the singer on each side of him/her. Such placement takes considerable time and is only useful if the membership of the group is consistently stable. It does not work for many choral groups that have a fluctuation of membership such as church choirs and y'all-come choruses.

The mixed seating arrangement works well with music which tends to emphasize a spatial relationship of sound. Seating by voice section works well with music that emphasizes blocks of sound or is polyphonic. Most choral music fits into the latter category. Many choral groups today, however, use the former method of seating to performs works in this latter category.

Lloyd

Lloyd W. Hanson, DMA
Professor of Voice, Pedagogy

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School of Performing Arts
Northern Arizona University
Flagstaff, AZ 86011

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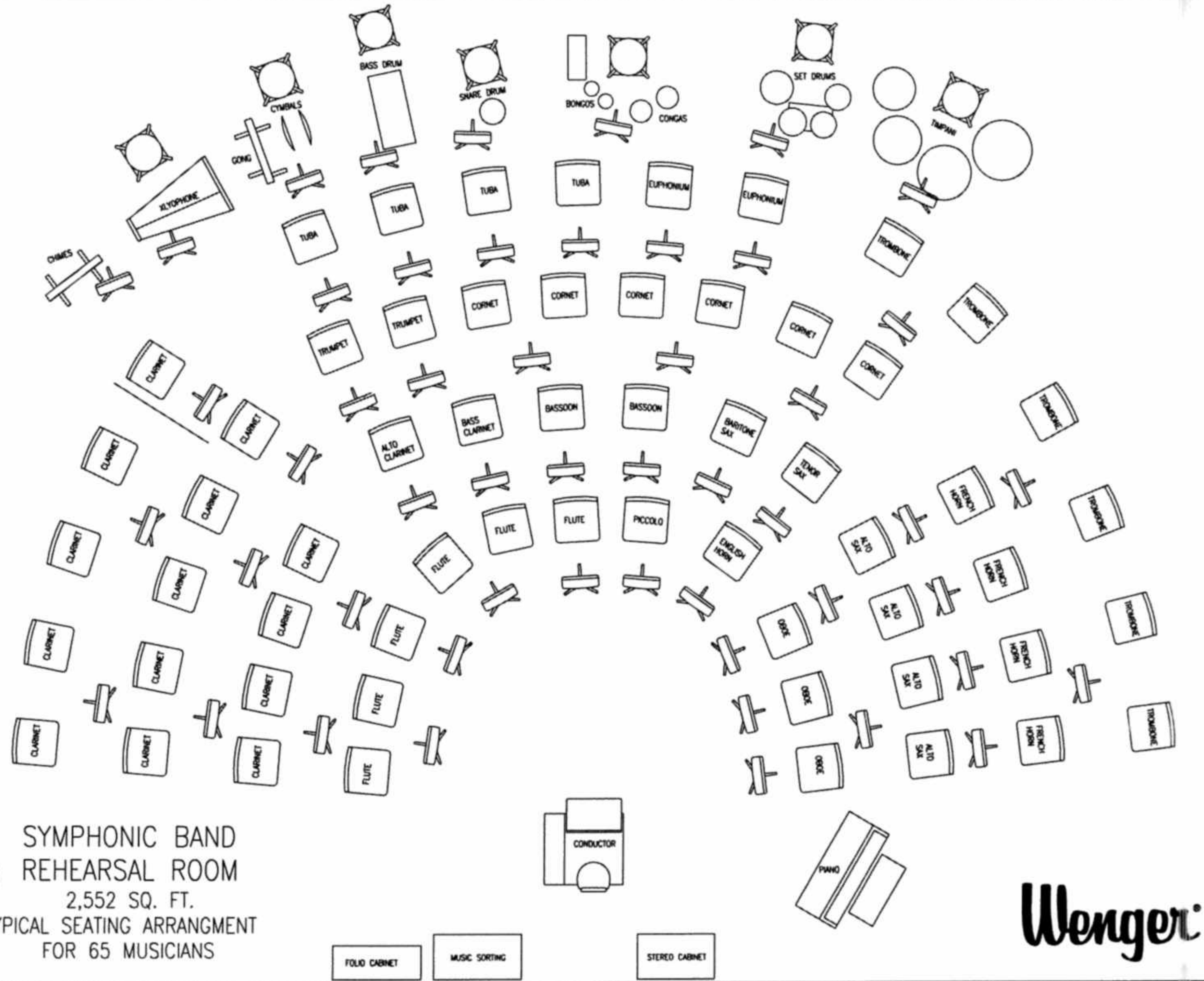
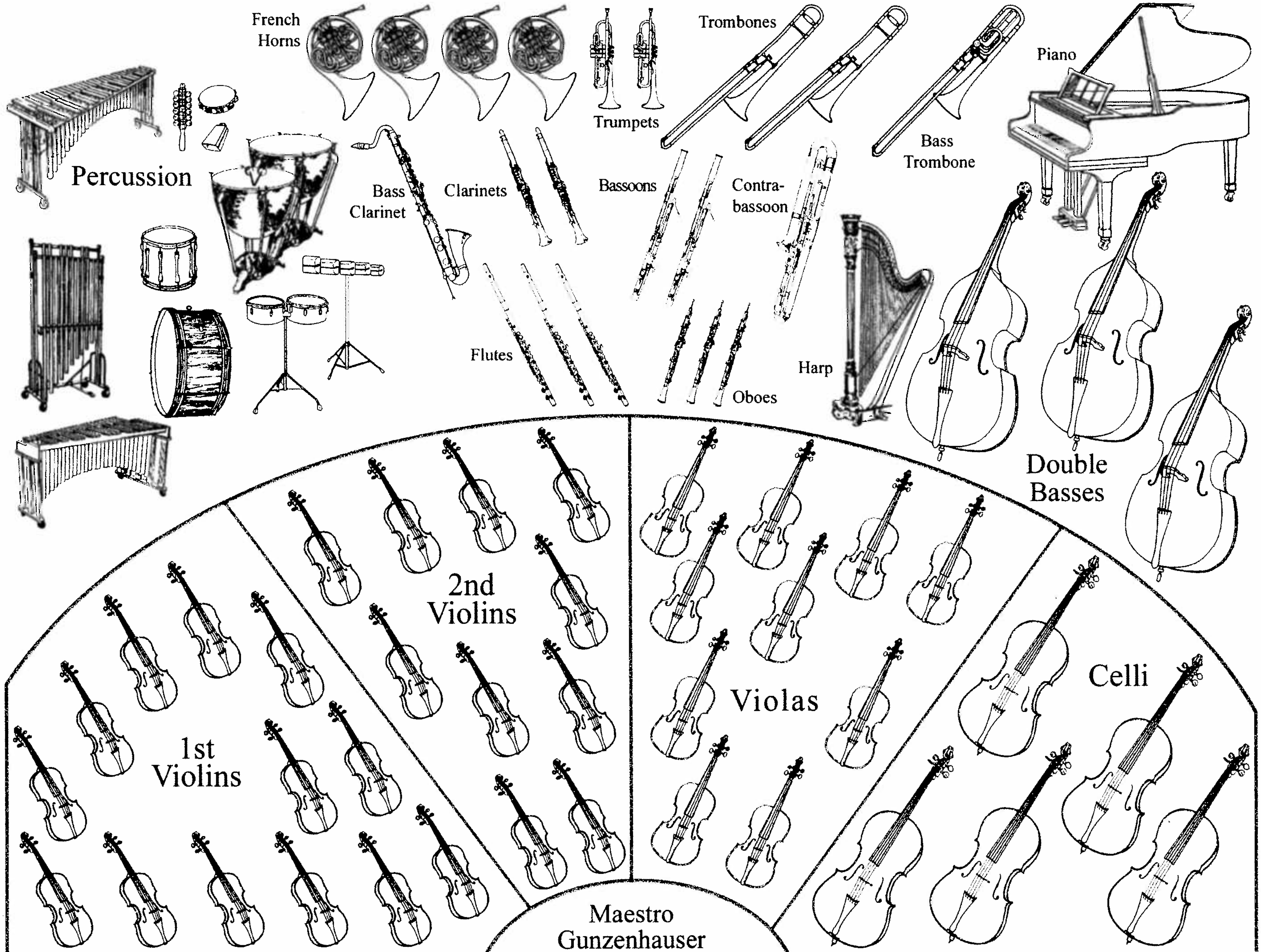
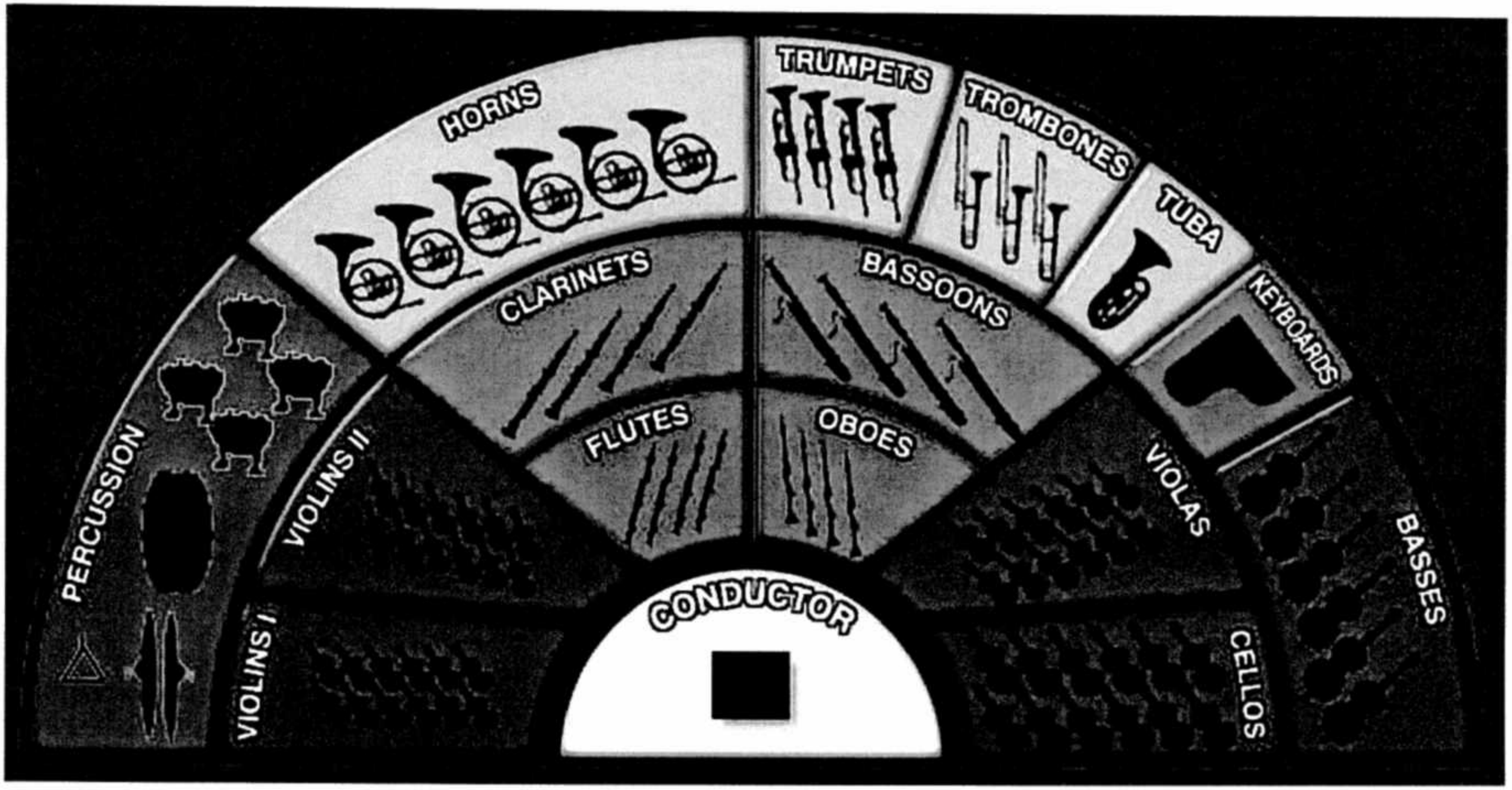


SYMPHONIC BAND
REHEARSAL ROOM
2,552 SQ. FT.
TYPICAL SEATING ARRANGMENT
FOR 65 MUSICIANS



LANCASTER SYMPHONY ORCHESTRA SEATING CHART



Seating Arrangements

There are several accepted arrangements for symphony orchestra seating; however, the first violins are always to the conductor's left and the percussion in the back of the orchestra. The position of the other instruments often varies depending on the conductor's preference and the acoustical qualities of the performance space.

Size

Generally, a full symphony orchestra has 75 to 90 members (sometimes smaller for Baroque- and Classical-period works, sometimes larger for late-Romantic, 20th or 21st century works). An orchestra is comprised of four sections: String Section - the largest group of the orchestra, with approximately 14 first violins, 12 second violins, 10 violas, 8 cellos, 8 double basses; Woodwinds - piccolo, 2 flutes, 2 oboes, English horn, 2 clarinets, bass clarinet, 2 bassoons, contrabassoon; Brass - 4 French horns, 4 trumpets, 3 trombones, tuba; Harps - 1 or 2; Percussion - timpani or kettledrums, bass and side drum, glockenspiel, triangle, cymbals, etc.

These instruments vary depending on the composer's orchestration and the conductor's interpretive decisions; certain compositions require additional instruments (according to the composer's orchestration), such as another French horn, a saxophone, supplementary percussion, a piano (not as a solo instrument, referred to as orchestra piano), an organ, etc. Also, the composer may specify fewer standard instruments than are normally employed.

Concertmaster

The "first-chair" violinist (to the conductor's immediate left) supervises the tuning of the orchestra and is a vital liaison between the conductor and the orchestra.

Principal Player

The lead player of each orchestral section who is required to guide the section and who performs any solo parts written for that particular instrument.

Section Player

Members of each section other than the principal.

Tuning

Just before the concert begins, the orchestra tunes to the note "A" that is initially provided by the principal oboe and then supervised by the concertmaster.

The Instruments

The String Section

The *violin* is the highest-pitched member of the string choir; the viola, somewhat larger than the violin, is lower in range; the *violoncello* (popularly known as cello and pronounced "chello"), is lower in range than the viola, notable for its lyrical quality and dark resonance; the *double bass* , the largest member of the string choir and the lowest in range, furnishes vital support for the entire orchestra. They are all played with a bow, causing the string to vibrate, except when the composer indicates "pizzicato" ("plucked") strings. Traditionally, the player bows with the right hand. The left hand is used to press down or "stop" the string, changing the length of the string that vibrates which in turn alters the pitch produced. "Double-stopping" involves playing two strings simultaneously; when three or four strings are played simultaneously, it is called "triple- or quadruple-stopping" (each level of stops is progressively more difficult). The hair of the bow is rubbed with a substance known as rosin so that it will better grip the strings. The string section makes up approximately 70% of a symphony orchestra. [ ]

The Woodwind Section

With these instruments the tone is produced by a column of air vibrating within a pipe that has holes on its side. When one or another of these holes is opened or closed, the length of the vibrating air column within the pipe is changed, thus changing the pitch. Nowadays, they are not necessarily made of wood, but the name has been retained.

The *piccolo* (from the Italian flauto piccolo, "little flute") has a piercing tone that produces the highest notes in the orchestra. The flute is the soprano voice of the woodwind choir. The present-day piccolo and flute is made of silver alloy (sometimes gold) rather than wood, as in the past (with one end closed), and it is held horizontally. To produce a sound, the player positions his or her lips (known as embouchure) across a mouth hole cut in the side of the pipe.

The *oboe* is made of wood. Its mouthpiece is a double reed (two pieces of cane bound together, leaving an extremely small passage for air). Because the pitch of the oboe is not easily subject to change, thus is more stable, it is chosen to sound the note "A" for the other instruments to tune the orchestra. The English horn is an alto (lower) oboe. Amusingly, it is neither English nor a horn! - another one of those idiosyncrasies in music history.

The *clarinet* has a single reed, fastened against a wooden mouthpiece, leaving a small space for the passage of air. The bass clarinet is one octave lower in range than the clarinet.

The *bassoon* , a double-reed instrument, has a weighty tone in the low register, a sonorous tone in the middle and reedy and intense in the upper. The contrabassoon (or double bassoon) produces the lowest tone in the orchestra. Its tube, over sixteen feet in length, is folded four times around for practical reasons. Like the double bass in the string section, it supplies orchestral support and foundation for the harmony. [ ]

The Brass Section

The *French horn* , generally referred to simply as *horn* , is descended from the ancient hunting horn. Its golden resonance lends itself to a variety of uses, soft and loud, though best in sustained utterances.

The *trumpet* , highest pitch in the brass choir, possesses a firm, brilliant timbre.

The *trombone* (an Italian word that means "large trumpet") combines the brilliance of the trumpet with the majesty of the horn. Unlike the valves used by the horn and trumpet to alter pitch, the trombone has a moveable U-shaped slide that alters the length of the vibrating air column and consequently the pitch produced.

The *tuba* is the bass of the brass choir, furnishing a foundation for the harmonic structure. It too utilizes a valve system to alter the pitches or notes produced. [ ]

The Percussion Section

This section comprises a variety of instruments that are made to sound by striking or shaking, and made of metal or wood; others, such as the drums, attain vibration by striking a stretched skin. Percussion instruments fall into two categories: those that can be tuned to specific pitches and those that can only produce a single sound (unpitched).

Tuned percussion most often includes:

1. *timpani* (also known as kettledrums), which are generally used in sets of two or three (each tuned to a different pitch), and are played with two padded sticks;
2. *glockenspiel* (German for "set of bells") consists of a series of steel, horizontally tuned plates of various sizes; the player strikes these plates with mallets that produce a bright metallic sound;
3. *Celeste* , who in appearance resembles a miniature upright piano, is a kind of glockenspiel that is operated by a keyboard, thus the steel plates are struck by small hammers that produce a more fragile sound.

Unpitched percussion include a snare drum played with drumsticks, a bass drum, played with a large, soft-headed stick, the tambourine, chimes, wood block, castanets, triangle, cymbals, etc. Generally, from three to five players take care of the percussion.

A composer orchestrates (assigning of instruments) a work depending on the particular sound desired. Each instrument, with its unique timbre and capability, provides a different color and character to the composition. [ ]

Medieval Period

(before 1450)

Music developed during the Gothic or Medieval period, including Gregorian Chant, was developed and refined over several centuries. This era covers the period 1000-1450. Music of the Medieval period is, for the most part, sacred, and characterized by the slow development of more rhythmic independence between voices in polyphonic textures. This arose from the monophonic style of Gregorian Chant and the more straight-forward multiple voice textures of organum.

Because ancient composers often did not affix their names to their compositions, many of the composers of this era are unknown to us, and, even if a name can be associate with a particular work, very little may be known about the specifics of that composer's life. However, a few major composers from this era are known to us, including Abbess Hildegard von Bingen, Perotin Magnus, and Guillaume de Machaut, among others.

Renaissance Period

(1450 - 1600)

As all forms of art, including music, the renaissance marked the rebirth of humanism, and a revival in cultural achievements for their own sake. Musical innovations were quickly disseminated, primarily facilitated by the advent of music printing, and thus the development of music theory and practice was likewise propelled forward. This period covers the last half of the 15th century, and 16th century, inclusive. With the Renaissance, more complicated and broader harmonic and contrapuntal structures emerge. Though the musical forms employed are still largely liturgical, the late Renaissance does see a great increase in sophistication for instrumental composition, as well as the emergence of secular madrigals, dramatic works and the first operas.

Many of these changes were pioneered with the music of Franco-Flemish composers including Johannes Ockeghem, Guillaume Dufay and Josquin des Prez. The period culminated in the music of Giovanni Palestrina, Claudio Monteverdi, William Byrd, Roland de Lassus, and many others, as the musical styles spread throughout Europe.

P E R I O D S   O F   M U S I C   H I S T O R Y

Baroque 1600 - 1750

Characteristics of music: Music of the Baroque period was decorative and filled with ornamentations (much like the fine art of that time). The music contained very few dynamic markings and tempos remained the same for the entire piece.

Size of Orchestras: Orchestras during this time were small and consisted of perhaps four 1st violins, four 2nd violins, 2 violas, two celli, and one bass. When called for, a small wind section (one player per part) was used. Timpani was used sparingly in the percussion section.The total number of musicians ranged from 18-24.

Conductors: Because orchestras were small and works contained little change in tempo or dynamic, no conductors were needed. In most cases, the concert master or harpsichordist used his head or free hand to begin the piece and give the final cutoff. Jean-Baptiste Lully (1632-1687) used to pound the ground with a heavy wooden staff in order to keep time for his orchestra. On one occasion, he missed the floor hitting his foot. His wound was so severe, it did not heal; gangrene resulted and eventually he died from his injury.

Famous Composers:
Vivaldi (1678-1741),
George Frederick Handel (1685-1759)
Johann Sebastian Bach (1685-1750)
Johann Pachelbel (1653-1706)

Classical 1750-1825

Characteristics of music: Music of the Classical period was much more reserved, intellectual and rational sounding. The ornamentations of the Baroque period had definitely fallen out of style. It was as though the musical pendulum had swung completely the other way to a much more controlled style of composition.

Size of Orchestras: In the early Classical period, the string sections of orchestras began to grow in number. In the late Classical period - Beethoven's time- orchestras were substantially larger in all sections of the orchestra. The total number of musicians ranged from 30-50 and in some cases was even higher

Conductors: Musicians were still experimenting with ways to keep large numbers of players in time. Instead of using a staff to pound noisily on the floor, conductors used rolled up pieces of music into a scroll and waved them in the air.

Famous Composers:
Joseph Haydn (1732-1809),
Wolfgang Amadeus Mozart (1756-1791)
Ludwig van Beethoven (1770-1827)
Franz Schubert (1797-1828)
Felix Mendelssohn (809-1847)

Romantic 1825 - 1900

Characteristics of music: Music of the Romantic period conveyed feelings. It had many more expression markings and tempo changes. Composers used nature as an inspiration for their works. In the Late Romantic period, composers from countries other than Germany, Austria and Italy (considered to be the center of all arts) used folktunes from their native countries as inspiration for their compositions. This provided a new flavor of music called Nationalism.

Size of Orchestras: Orchestras exploded during the Romantic Period. Large concert halls were built which could accommodate huge orchestras. String sections as large as 50-60 players were combined with a large compliment of woodwinds, brass, and percussion. Orchestras also began to use a standard of seating that is still used today.

Conductors: By now, conductors were a standard practice for orchestras. They would stand on a podium and use a wooden stick or baton to lead. Their function became more than just a time keeper. It was now the conductor's job to interpret the compositions and convey musical gestures to the musicians that would produce the desired musical effect.

Famous Composers:
Carl Maria von Weber (1768-1826)
Frederic Chopin (1810-1849)
Johannes Brahms (1833-1897)
Nationalistic Composers
Antonin Dvorak (1841-1904)
Edvard Grieg(1843-1907)
Peter Tchaikovsky (1840-1893)
Sergei Rachmaninoff (1873-1943)

MODERN 1900 TO PRESENT

Characteristics of music: Early in this period, composers tried to convey impressions created by sights, sounds, fragrances, and tastes. Composers broke the molds of traditional harmonies.

Size of Orchestra: Today, the size of an orchestra will vary according to the requirements of the piece it is performing. they can be as large as 100+ or as small as 24. Compositions to day may require an instrument not usually found in an orchestra - i.e. a saxophone.

Conductors: Today, we don't even think about an orchestra without imagining a conductor taking charge of all those musicians! His role has evolved into so much more than a time keeper. With hundreds of years of music in the past, it is the responsibility of the modern day conductor to maintain music integrity when conducting everything from Bach to Copland. Conductors must be well versed in theory, music history, and foreign languages. Because all music is living, they must bring artistic meaning to the notes on the page and convey their musical interpretation to the musicians before them. They are also responsible for choosing an interesting and creative program of music for their listening audience.

Famous Composers:
Claude Debussy (1862-1918)
Maurice Ravel (1875-1937)
Igor Stravinsky (1882-1971)
Sergei Prokofiev (1891-1953)
Dmitri Shostakovich (1906-1975)
Edward MacDowell (1860-1908)
Aaron Copland (1900-1990)
George Gershwin (1898-1937)

Baroque Period 1600 - 1750	Classical Period 1750 - 1825	Romantic Period 1825 - 1900	MODERN PERIOD 1900 TO PRESENT

1600 — 1650 — 1700 — 1750 — 1800 — 1850 — 1900 — 1950 — 2000

1600- Folding fan invented in Japan
1609- Henry Hudson led an expedition to America for the Dutch East India Company.
1682- Philadelphia Founded
1704- 1st U.S. Periodical
1711- First Piano
1732- George Washington Born
1763- Steam Engine
1776- Declaration of Independence
1787- Pennsylvania becomes a state
1802- Steam Boat
1823- Monroe Doctrine
1829- Locomotive
1844- Telegraph
1860- Civil War begins
1869- Transcontinental Railroad
1876- Telephone
1878- Electricity
1896- Radio
1896- 1st Automobile
1903- First Flight
1914- Panama Canal
1929- The Great Depression
1939- Television
1945- Atomic Age begins
1945- United Nations founded
1960- First Outer Space flights
1960- Computer age begins
1990- cell phones

6

Harmonics
(har-MAH-niks)

---

1. The natural pure sounds that are a part of any musical tone; the overtones that are present with any fundamental tone. That is, the series of sounds heard when any note is sounded, consisting of the original note, which is the **fundamental** or first **harmonic**, then the tone an octave above that called the first overtone (also called the second **harmonic**), then the fifth above the first overtone, then the perfect fourth above that, then the major third above that, etc., in increasingly smaller intervals.
2. High notes that are achieved on instruments of the violin family when the performer lightly places his finger exactly in the middle of the vibrating string.

Overtone Series
(Chart of harmonics on C)

• Darkened notes denote approximate pitches. These tones are considered out of tune.

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Design-Build

What is Design-Build?

Design-build means contracting with a single entity for performing both design and construction on an entire project.

The attractiveness of design-build lies mainly in the promise of innovation stemming from the designer/builder collaboration. If the process is applied to the right project, with the right controls in place, the public gets a quality product in a shorter time.

NOISE CONTROL IN DUCTS AND DIFFUSERS

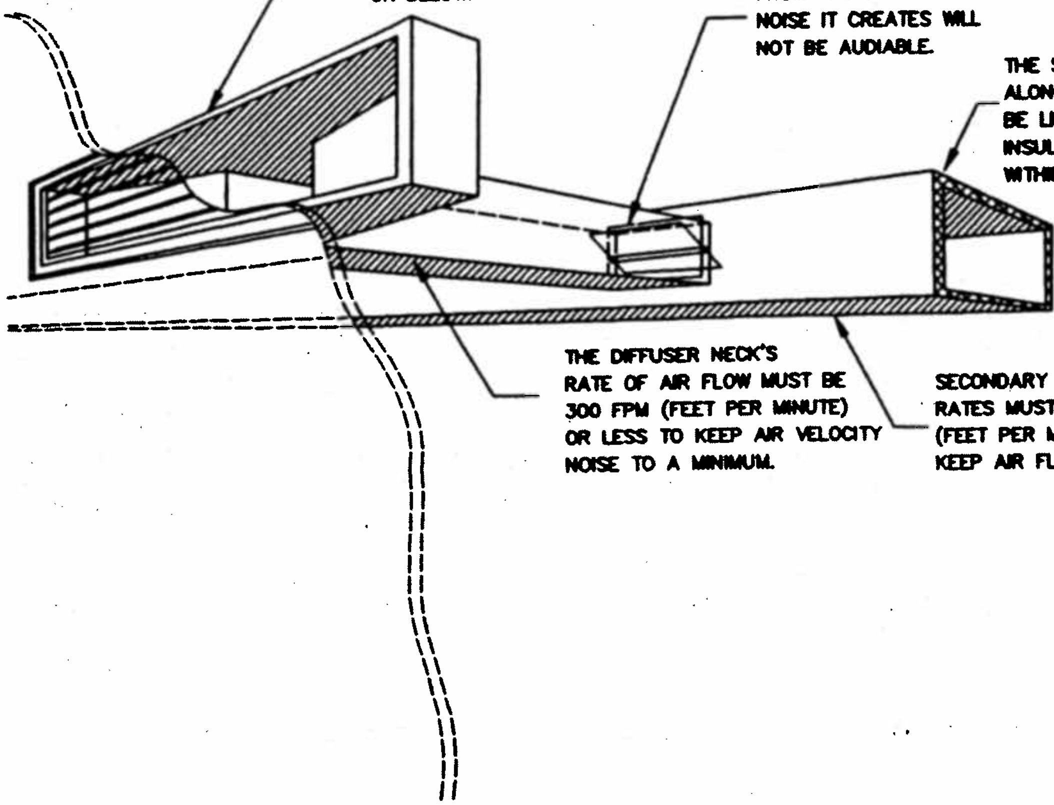

ILLUSTRATION AC-5

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Basic Acoustics

decibels

Sound pressure and signal levels (power and voltage) are often measured using a decibel scheme, or dB for short. dB's are logarithmic in nature and thus tend to compress the range of signal levels. For voltage and current gain, use the form Av□ = 20*log10 Av, and for power gain use the form G□ = 10*log10 G. For specific signal levels, replace the gain value with the ratio of the desired signal to the desired reference. Common references are 1 volt (dBV), .775 volts (dBu), 1 watt (dBW), and 1 milliwatt (dBm). Thus, for specifying a power in dBm, use the equation P□ = 10*log10 (P/1 mW). Positive dB values represent increases in level while negative values denote decreases in level. To place this into a more familiar listening level context, 1 dB represents a just discernable change in volume under good conditions for trained listeners. 3 dB is a factor of two for power, but only represents a clearly discernable change in volume for the average listener. To double perceived volume, a level change of 8 to 10 dB is required. Note that 10 dB represents a factor of 10 change in power. It is clear then that the human hearing mechanism is sort of □super logarithmic□. When dealing with **sound** pressure levels, 0 dB-SPL represents the quietest **sound** pressure that a human with good hearing can discern. Conversational levels are usually in the 70 dB-SPL range. Workplace values that exceed approximately 90 dB-SPL come under OSHA control in the USA, and time limits are placed on exposures without hearing protection. The higher the **sound** pressure, the shorter the allowable exposure. Excessive exposure to high **sound** pressures may cause hearing damage. Generally, 120 dB-SPL is agreed to be the □threshold of feeling□ and approximately 140 dB-SPL is considered to be the □threshold of pain□. (Different sources may quote slightly different values.)

Acoustic Waves

Sound is an acoustic pressure wave. Some device or action imparts a pressure differential in a medium (air, water, etc.), and that pressure propagates through the medium. A classic example of a wave is the expanding ripples resulting from a pebble cast into water. Just as there are crests there are also valleys. This is an example of a transverse wave. In a transverse wave, the particle motion is at right angles to the direction of the wave. Imagine a bobber on the surface of the water. As the wave passes, the bobber moves up and down. In air, **sound** can be viewed as an alternating pressure superimposed upon the existing air pressure. If you think of voltage as electrical pressure then this is similar to the voltage that would be seen at the collector of a transistor amplifier where the AC signal rides upon the fixed DC bias. **Sound** is an example of a longitudinal wave; where the motion is in line with the direction of propagation. A good visual example of a longitudinal wave can be demonstrated by stretching a slinky between two people and then pushing on one end. The resulting compression can be seen to travel along the direction of the slinky. It is important to understand that a medium is required to transmit an acoustic pressure wave. As there is no medium, there is no such thing as **sound** in outer space, in spite of what most science fiction movies portray. In space, explosions are silent. It□s like casting a pebble onto a dry lake bed; there will be no ripples. The medium will directly affect the transmission of the pressure wave, most notably in terms of velocity of propagation and absorption of various frequencies. Note that the particle velocity (i.e., movement of molecules) is considerably smaller than the wave velocity. The velocity of **sound** in air at sea level on a balmy day is about **1130** feet per second. The warmer the air, the faster the velocity. In contrast, the **speed** of **sound** in water, a denser medium, is on the order of 4750 feet per second.

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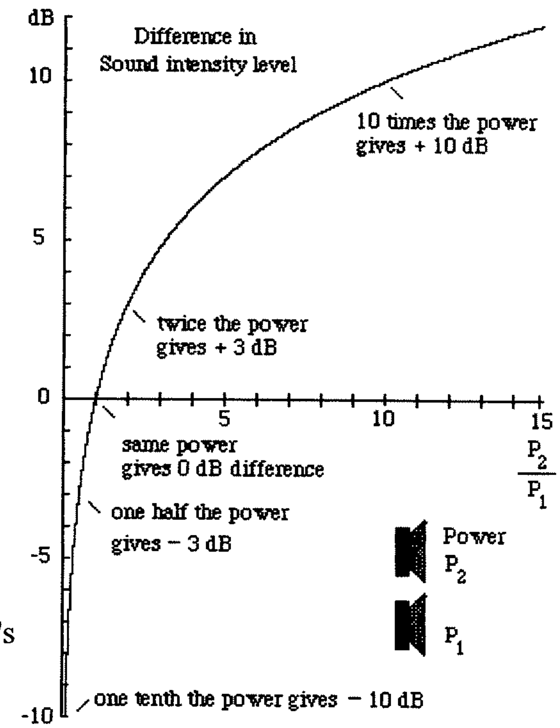
What is a decibel?

And what are the different types of decibel measurement: dB, dBA, dBC, dBi? How are they related to loudness? (A related page allows you to measure your hearing response and to compare with standard hearing curves.)



Plot of 10 log (P_2/P_1)

Definition and examples

The decibel (**dB**) is used to measure sound level, but it is also widely used in electronics, signals and communication. The dB is a logarithmic unit used to describe a ratio. The ratio may be power, sound pressure, voltage or intensity or several other things. Later on we relate dB to the **phon** and the **sone** (other units related to loudness). But first, to get a taste for logarithmic units, let's look at some numbers:

For instance, suppose we have two loudspeakers, the first playing a sound with power P_1, and another playing a louder version of the same sound with power P_2, but everything else (how far away, frequency) kept the same.

The **difference in decibels** between the two is defined to be

$$10 \log (P_2/P_1) \text{ dB} \qquad \text{where the log is to base 10.}$$

If the second produces twice as much power than the first, the difference in dB is

$$10 \log (P_2/P_1) = 10 \log 2 = 3 \text{ dB}.$$

If the second had 10 times the power of the first, the difference in dB would be

$$10 \log (P_2/P_1)= 10 \log 10 = 10 \text{ dB}.$$

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If the second had a million times the power of the first, the difference in dB would be

$$10 \log (P_2/P_1) = 10 \log 1000000 = 60 \text{ dB}.$$

This example shows one feature of decibel scales that is useful in discussing sound: they can describe very big ratios using numbers of modest size. But note that the decibel describes a *ratio*: so far we have not said what power either of the speakers radiates, only the ratio of powers.

Sound pressure, sound level and dB. Sound is usually measured with microphones and they respond (approximately) proportionally to the sound pressure, p. Now the power in a sound wave, all else equal, goes as the square of the pressure. (Similarly, electrical power goes as the square of the voltage.) The log of the square of x is just 2 log x, so this introduces a factor of 2 when we convert to decibels for pressures. The difference in sound pressure level between two sounds with p_1 and p_2 is therefore:

$$20 \log (p_2/p_1) \text{ dB} = 10 \log (p_2^2/p_1^2) \text{ dB} = 10 \log (P_2/P_1) \text{ dB}$$ where again the log is to base 10.

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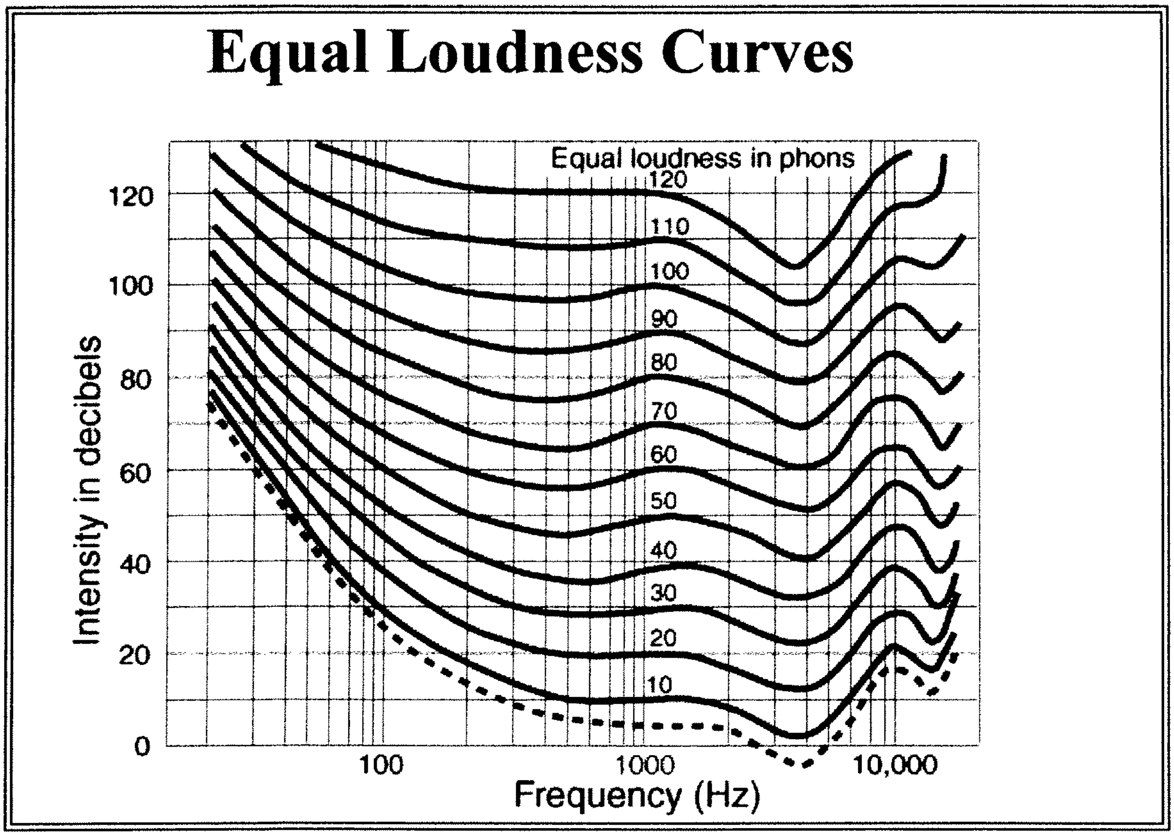
Equal Loudness Curves
Equal loudness in phons
120
110
100
90
80
70
60
50
40
30
20
10
Intensity in decibels
0
20
40
60
80
100
120
100
1000
10,000
Frequency (Hz)

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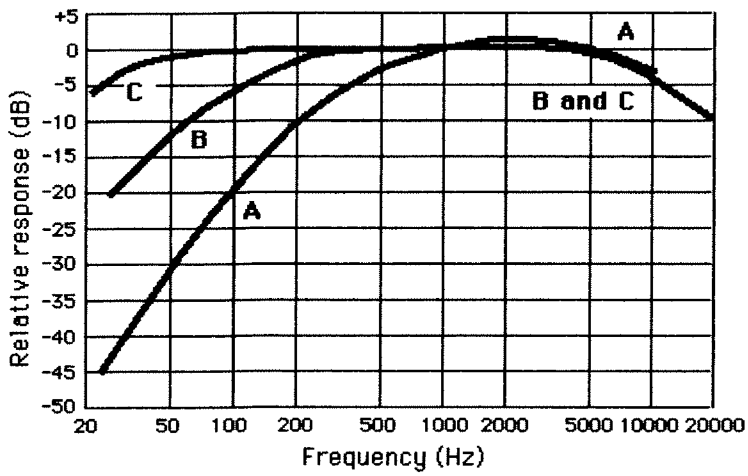
A,B, and C Contours



Standard filter contours are used to make the instrument more nearly approximate the normal human ear. The different contours were intended to match the ear at different sound intensities.

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Filter contour details: A B C

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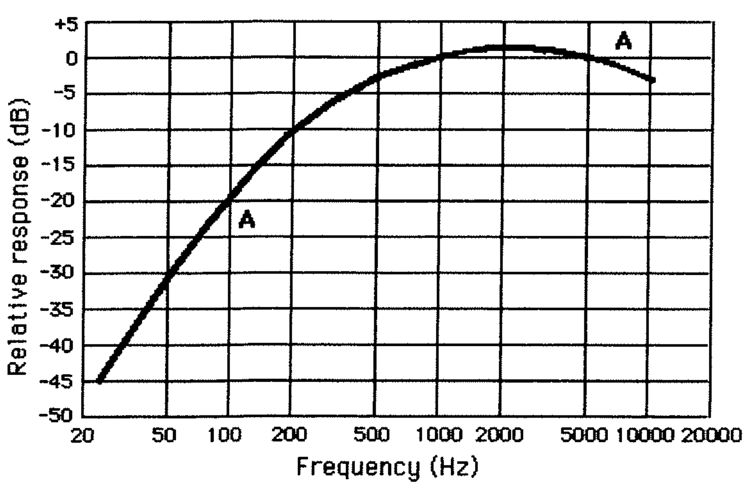
A Contour Filter



The A-contour filters out significantly more bass than the others, and is designed to approximate the ear at around the 40 phon level. It is very useful for eliminating inaudible low frequencies.

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Other contour filters dBA examples

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Sound Measurement in dBA

When making practical assessments of the sound level of a concert or as a part of a general survey of ambient sound levels, the type of measurement which is usually made is that of the level in dBA. This measurement is made with a sound level meter with an A contour filter which provides the best instrument match of the ear's equal loudness curves for soft sounds in the neighborhood of 40 dB. When this filter, (which is one of the standard contour filters of most sound level meters) is used, the levels should be recorded as dBA rather than dB. The unit dB implies that all frequencies in the audible frequency range are treated equally - something very different from what the ear does. A good practice in sound level surveys is to measure all levels in both dBA and in the flat-response mode where the intensity in decibels (dB) is measured directly. Measurements made in dBA approximate the loudness level in phons and are practical to make with a standard meter.

dBA Measurement Examples	Plot of A contour filter response

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B Contour Filter

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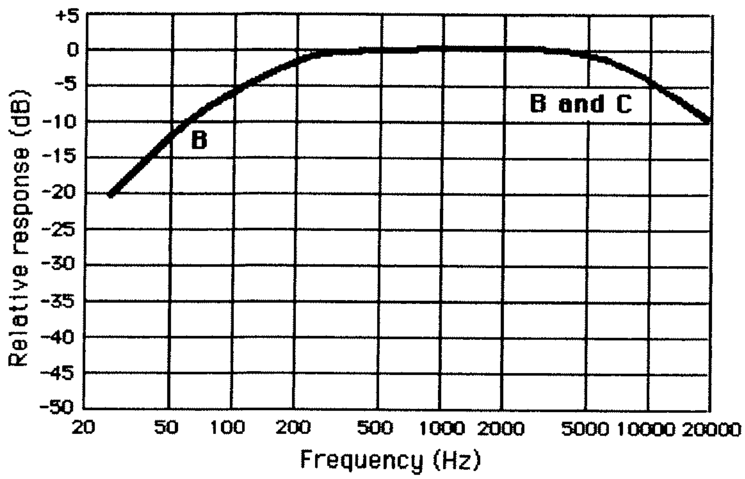

The intermediate B-contour aproximates the ear for medium loud sounds. It is rarely used.

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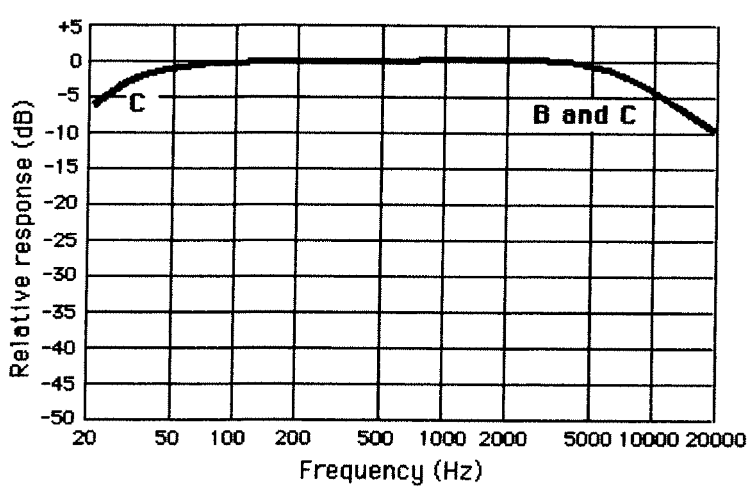
C Contour Filter



The C-contour does not filter out as much of the lows and highs as the other contours. It approximates the ear at very high sound levels and has has been used for traffic noise surveys in noisy areas.

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Phons

Two different 60 decibel sounds will not in general have the same loudness

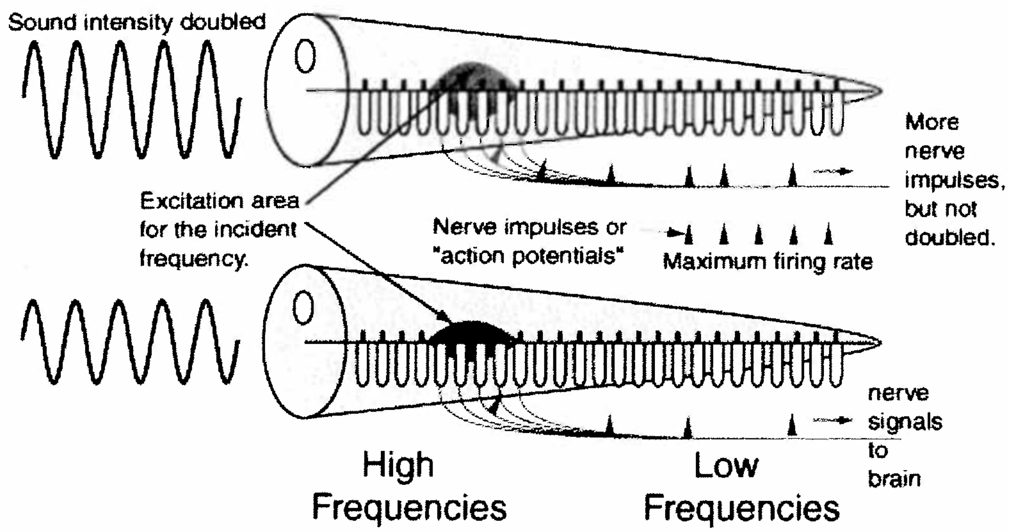
Saying that two sounds have equal intensity is not the same thing as saying that they have equal loudness. Since the human hearing sensitivity varies with frequency, it is useful to plot equal loudness curves which show that variation for the average human ear. If 1000 Hz is chosen as a standard frequency, then each equal loudness curve can be referenced to the decibel level at 1000 Hz. This is the basis for the measurement of loudness in phons. If a given sound is perceived to be as loud as a 60 dB sound at 1000 Hz, then it is said to have a loudness of 60 phons.

60 phons means "as loud as a 60 dB, 1000 Hz tone"

The loudness of complex sounds can be measured by comparison to 1000Hz test tones, and this type of measurement is useful for research, but for practical sound level measurement, the use of filter contours has been commonly adopted to approximate the variations of the human ear.

"Rule of Thumb" for Loudness

A widely used "rule of thumb" for the loudness of a particular sound is that the sound must be increased in intensity by a factor of ten for the sound to be perceived as twice as loud. A common way of stating it is that it takes 10 violins to sound twice as loud as one violin. Another way to state the rule is to say that the loudness doubles for every 10 phon increase in the sound loudness level. Although this rule is widely used, it must be emphasized that it is an approximate general statement based upon a great deal of investigation of average human hearing but it is not to be taken as a hard and fast rule.



Why is it that doubling the sound intensity to the ear does not produce a dramatic increase in loudness? We cannot give answers with complete confidence, but it appears that there are saturation effects. Nerve cells have maximum rates at which they can fire, and it appears that doubling the sound energy to the sensitive inner ear does not double the strength of the nerve signal to the brain. This is just a model, but it seems to correlate with the general observations which suggest that something like ten times the intensity is required to double the signal from the innner ear.

One difficulty with this "rule of thumb" for loudness is that it is applicable only to adding loudness for identical sounds. If a second sound is widely enough separated in frequency to be outside the critical band of the first, then this rule does not apply at all.

While not a precise rule even for the increase of the same sound, the rule has considerable utility along with the just noticeable difference in sound intensity when judging the significance of changes in sound level.

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Critical Band

When two sounds of equal loudness when sounded separately are close together in pitch, their combined loudness when sounded together will be only slightly louder than one of them alone. They may be said to be in the same critical band where they are competing for the same nerve endings on the basilar membrane of the inner ear. According the the place theory of pitch perception, sounds of a given frequency will excite the nerve cells of the organ of Corti only at a specific place. The available receptors show saturation effects which lead to the general rule of thumb for loudness by limiting the increase in neural response.

If the two sounds are widely separated in pitch, the perceived loudness of the combined tones will be considerably greater because they do not overlap on the basilar membrane and compete for the same hair cells. The phenomenon of the critical band has been widely investigated.

Backus reports that this critical band is about 90 Hz wide for sounds below 200 Hz and increases to about 900 Hz for frequencies around 5000 Hertz. It is suggested that this corresponds to a roughly constant length on the basilar membrane of length about 1.2 mm and involving some 1300 hair cells. If the tones are far apart in frequency (not within a critical band), the combined sound may be perceived as twice as loud as one alone.

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Acoustic Rating Terms

TL Transmission Loss. Stated in dB. When a construction material is placed between a sound source and a receiving room. The reduction of sound level is the TL.

STC Sound Transmission Class. Assigns a single number to the effectiveness of a material in stopping sound over the entire curve of Transmission Loss for speech (125 Hz – 4000 Hz)

Mass Law STC increases by 5 points for every doubling of a material's surface weight stated in pounds per square foot.

NIC Noise Isolation Class. Stated in dBA, this rating is similar to the material rating of STC, but it rates the sound isolation capabilities of the entire room, not just a single material or object. NIC for Music spaces should be between 36 – 40 dBA

NC Noise Criteria. A single number average of background noise levels at 1,000, 2,000, & 4,000 Hz but plotted at eight octave-bands from 63 Hz to 8,000 Hz

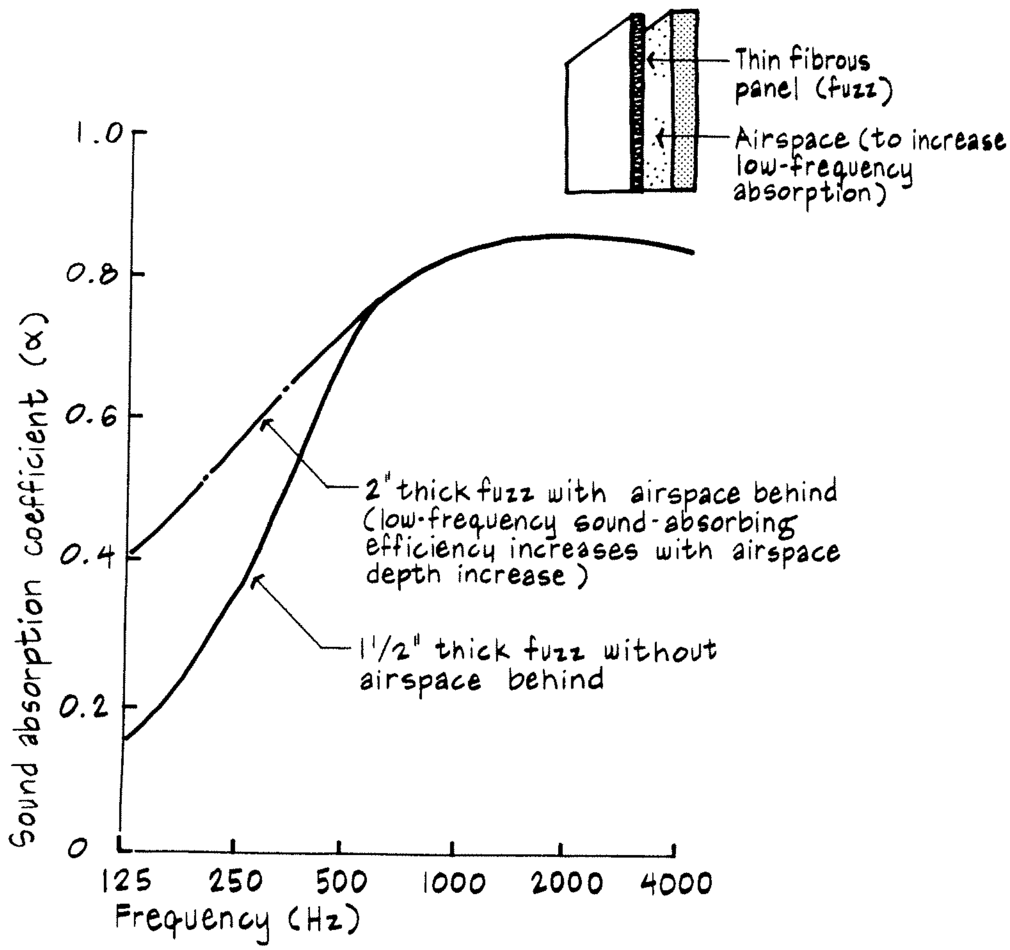
NRC Noise Reduction Coefficient. The arithmetic average of the sound absorption coefficient of a material measured at 250, 500, 1,000, and 2,000 Hz. Because it's an average, two materials can absorb quite differently at a certain frequency and still have the same NRC rating. The elimination of very low, and very high frequencies from the NRC rating make this scale less than ideal for rating materials in music spaces.

SPL Sound Pressure Level. Loudness of a sound expressed in dB.

RELATIVE EFFICIENCY OF SOUND ABSORBERS

The basic types of sound absorbers are porous materials, vibrating (or resonant) panels, and volume resonators (called *Helmholtz resonators*). Porous sound absorbers (thick materials or thin materials with airspace behind) should be placed at location of maximum compression for impinging sound waves (e.g., $\lambda/4$ distance from backup wall surface). Combinations of porous materials and vibrating panels or volume resonators can provide the uniform, or "flat," sound absorption with frequency required in recording or radio/TV studios.

Thin Porous Materials (Convert sound energy into heat by friction)



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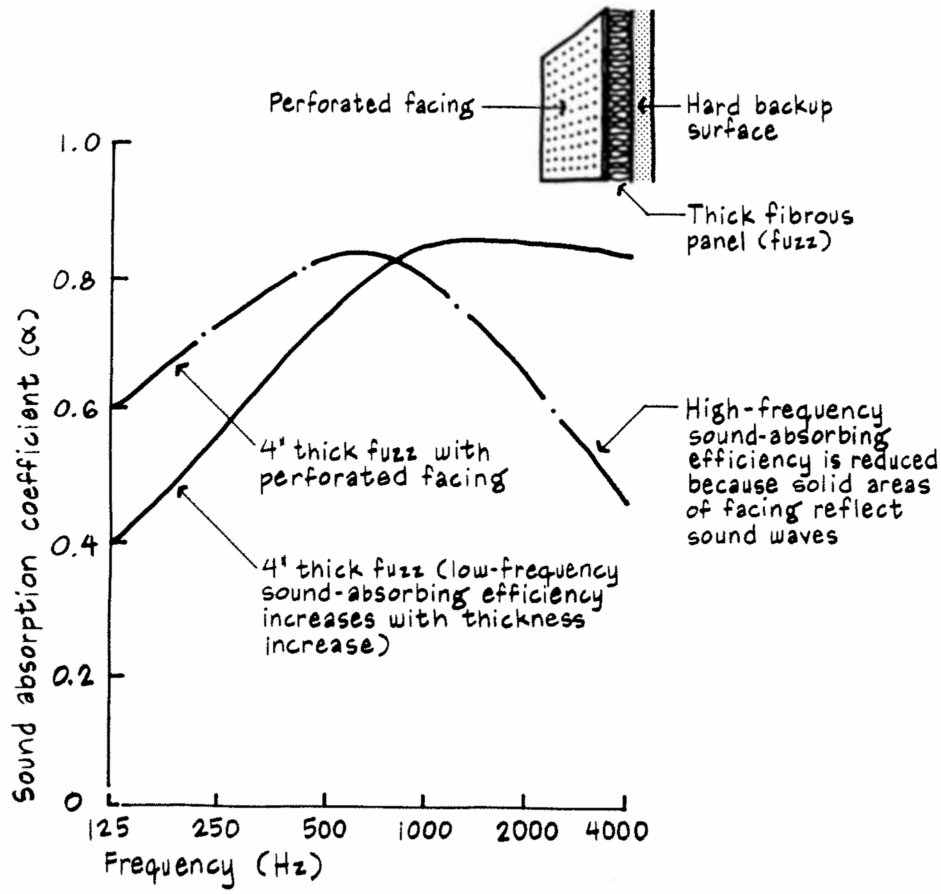
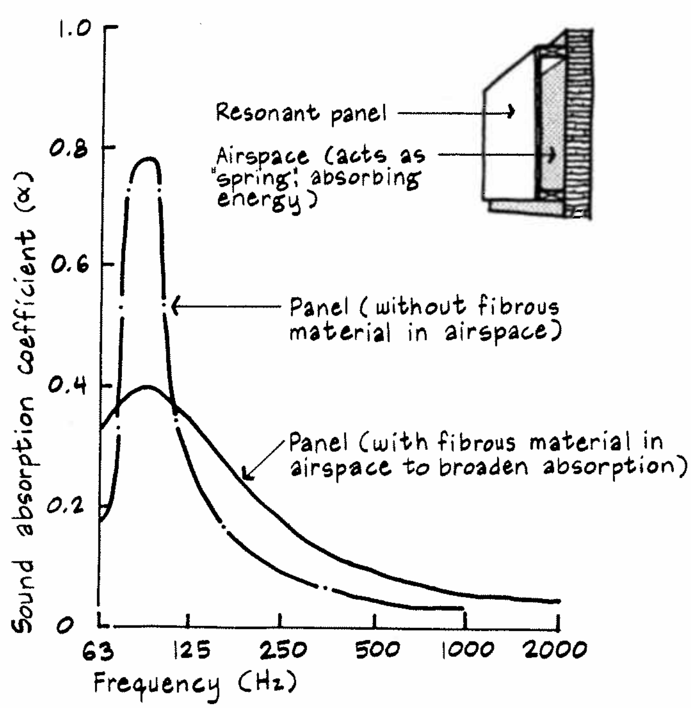
Thick Porous Materials



Vibrating Panels* (Convert sound energy into vibrational energy which is dissipated by internal damping and radiation)



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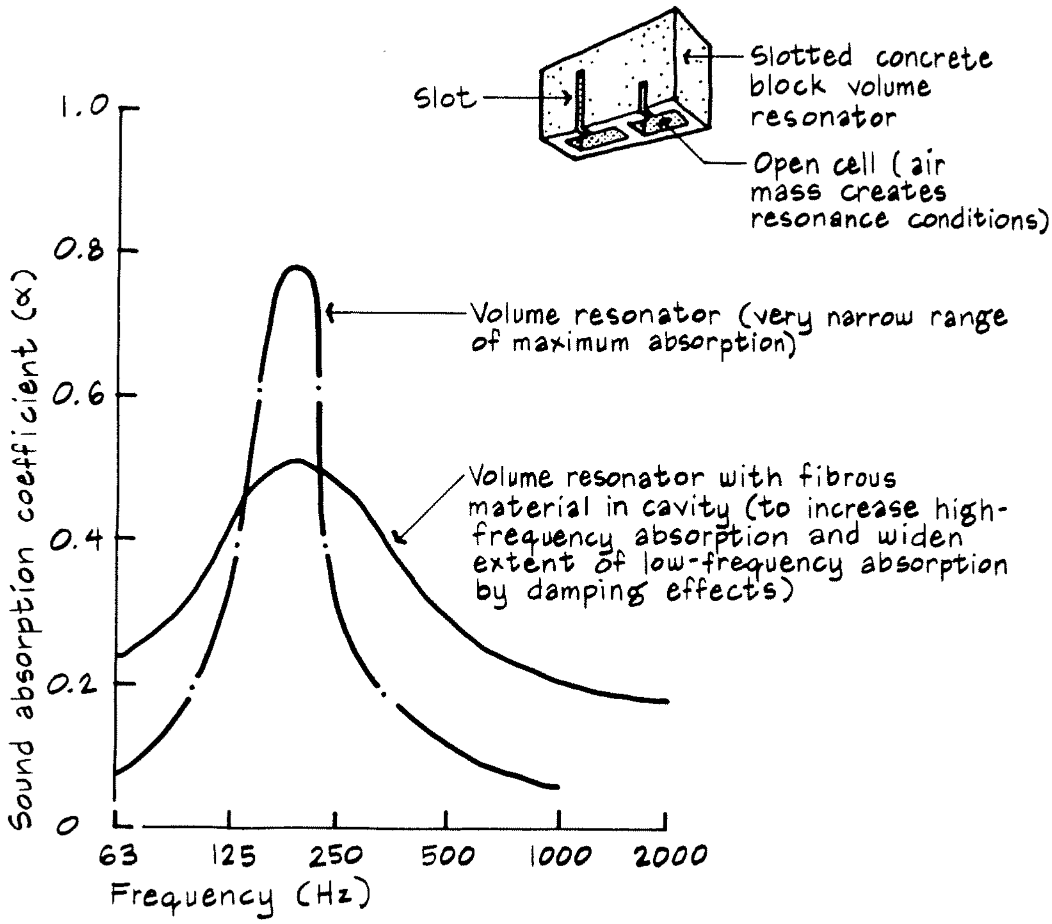
Volume Resonators* (Reduce sound energy by friction at opening and by interreflections within cavity)



*These specialized types of sound absorption can be used to supplement porous materials or to absorb specific low-frequency sound energy (e.g., 120-Hz "hum" from electrical equipment).

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OSHA NOISE EXPOSURE STANDARDS

NOISE AND VIBRATION ANALYSIS

OSHA issued its final hearing conservation rules on March 8, 1983. The addition of a hearing conservation program to the noise standard is an outgrowth of a revision first published in 1974. This final ruling has adopted a more performance-oriented approach and therefore is expected to save industry $81.4 million per year over the program proposed in early 1981.

Calling for exposure monitoring, audiometric testing, worker training, recordkeeping and the use, where necessary, of hearing protectors, the hearing conservation program covers all employees exposed to an eight-hour-time-weighted average sound level of 85 decibels (dB), except those employed in construction, agriculture, and oil and gas well drilling and servicing operations.

Employers must make hearing protectors available to workers exposed to noise above a TWA of 85 dB, but use of the protectors is optional unless the worker experiences a permanent, significant shift in his or her hearing level. Hearing protectors must be worn by all employees exposed to a TWA of 90 dB or more.

(Editor's note: On April 19, 1985, OSHA announced that it had resumed frill enforcement of a hearing conservation amendment protecting workers against noise-related hearing loss. The decision followed a November 8, 1984 U.S. Court of Appeals order which struck down the amendment on the grounds that the rule exceeded the authority of OSHA under the OSHAct because a distinction had not been made between occupational and non-occupational hearing loss, which may cause employers to be held responsible for hearing loss incurred off the job. The amendment covers workers (except in agriculture and construction) who are exposed to noise levels at or above 85 decibels over an eight-hour time frame.)

The final rule became effective April 7, 1983, and the required baseline audiometric tests must be completed by March 1, 1984. OSHA believes the primary benefit of the program to be a substantial reduction in the incidence of occupational hearing impairment in the population exposed to workplace noise. Additional benefits anticipated include workplace safety, reduced absenteeism, reduced medical costs, reduced workman's compensation payments and possibly a reduction in cardiovascular illness.

Information on noise control equipment and hearing protection has been developed by NIOSH and it available from several sources.

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Publications available from NIOSH:

- A Real-Ear Field Method for the Measurement of the Noise Attenuation or Insert-Type Hearing Protection NIOSH 76-18l)
- Survey of Hearing Conservation Programs in Industry (NIOSH 75-178) From the Superintendent of Documents:
- Compendium of Materials for Noise Control (GPO 0l7-033-0035-9)
- Industrial Noise Control Manual (GPO 0l7-033-00339-4)
- Prevalence of Middle Ear Disorders in Coal Miners (GPO 0l7-033-00384-0) From the National Technical Information Service:
- Effects of Noise on Nonauditory Sensory Functions and Performance (PB-266-247)
- A Field Investigation of Noise Reduction Afforded by Insert Type-Hearing Protectors (PB-299-319)
- Life of Personal Hearing Protectors and Attenuation Data (PB-267 -46l)
- A Report on the Performance of Personal Noise Dosimeters (PB-80-l76-084)
- A Survey of Hearing Loss in the Coal Mining Industry (PB-271-811)
- A Survey of Personal Protective Equipment Used in Foundries (PB-81-176-399)

Editor's note: NIOSH has terminated its voluntary testing and certification program for industrial sound level meters. (As of September 30, 1983, NIOSH certification labels are invalid.)

Requirements from the General Industry Standards

Occupational Noise Exposure (1910.95)
(a) Provide protection against the effects of noise exposure when sound levels exceed those in Table G-16 when measured on the A scale of a standard sound level meter at slow response.

When noise levels are determined by octave band analysis, the equivalent A-weighted sound level may be determined from Figure G-9.

BAND CENTER FREQUENCY IN CYCLES PER SECOND

Equivalent sound level contours. Octave band sound pressure levels may be

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converted to the equivalent A-weighted sound level by plotting them on this graph and noting the A-weighted sound level corresponding to the point of highest penetration into the sound level contours. This equivalent A-weighted sound level, which may differ from the actual A-weighted sound level of the noise, is used to determine exposure limits from Table G-16.

(b.1) When employees are subjected to sound levels exceeding those in Table G-16, utilize administrative controls (limit daily noise exposure through work scheduling) or engineering controls (5ractical and economically sound methods to reduce the Sound level at its source or in employees' hearing zones). If such controls fall to reduce noise levels below those shown, personal protective' equipment must be provided and used to reduce sound within the levels indicated.

(2) If the noise level involves interruptions of 1 second or less, it is to be considered continuous.

(3) In all cases, where the sound levels exceed the values shown in Table G-16, establish a continuing, effective hearing conservation program.

TABLE G-16	
PERMISSIBLE NOISE EXPOSURE	
Duration per day,hours	Sound level dbA slow response
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions $C_1/T_1 + C_2/T_2 ... C_a/T_a$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C_a indicated the total time of exposure at a specified noise level, and T_a indicates the total time of exposure permitted at that level.

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Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

(c) Hearing conservation program.

(1) Employers must administer a continuing, effective hearing conservation program, as described in (c) through (o) of this section whenever employee noise exposures equal or exceed an eight-hour time weighted average sound level (TWA) of 85 decibels (dB) measured on the A scale or, a dose of 50%. Employee noise exposures must be computed in accordance with Appendix A and Table G-16a without regard to any protection provided by the use of personal protective equipment.

(2) For purposes of paragraphs (c) through (u) of this section, an eight-hour TWA of 85 dB or a dose of 50% shall also be referred to as the "action level."

TABLE G-16a

A-weighted sound level, L(decibel)	Reference duration T(hour)
80	32
81	27.9
82	24.3
83	21.1
84	18.4
85	16
86	13.9
87	12.1
88	10.6
89	9.2
90	8
91	7
92	6.2
93	5.3
94	4.6
95	4
96	3.5
97	3.0
98	2.6
99	2.3
100	2
101	1.7
102	1.5
103	1.4
104	1.3
105	1
106	0.87
107	0.76
108	0.66
109	0.57
110	0.5
111	0.4
112	0.38
113	0.33

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114	0.29
115	0.25
116	0.22
117	0.19
118	0.16
119	0.14
120	0.125
121	0.11
122	0.095
123	0.082
124	0.072
125	0.063
126	0.054
127	0.047
128	0.041
129	0.036
130	0.031

(d) Monitoring.

(1) The employer must develop and implement a monitoring program when information indicates that any employee's exposure may equal or exceed the action level. (i) The sampling strategy must identify employees for inclusion in the hearing conservation pro gram and enable the proper selection of hearing protection. (ii) When area monitoring is inappropriate (due to sound level variations worker mobility, etc.) representative personal sampling must be used to meet sampling requirements.

(2)(i) All continuous, intermittent and impulsive sound levels from 80-130 dB must be included in the noise measurement. (ii) Monitoring instruments must be accurately calibrated.

(3) Monitoring must be repeated whenever a change in production, process, controls or equipment occurs such that (i) Additional employees are exposed: or (ii) Hearing protection may be rendered inadequate.

(e) Employee notification. The employer must notify each employee exposed at or above the eight hour TWA of 85 dB of the monitoring results.

(f) Observation of monitoring. Employers must provide affected employees of their representatives with an opportunity to observe any measurements of employee noise exposure conducted under (d).

(g) Audiometric testing program.

(1) Employers must establish and maintain an audiometric testing program as provided for by this paragraph by making audiometric testing available to all employees whose exposures equal or exceed an eight-hour TWA of 85 dB.

(2) The program must be free to employees.

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(3) (This paragraph sets the guidelines as to who may administer the audiometric tests.)

(4) All audiograms obtained must meet the requirements of Appendix C.

(5) Baseline audiograms. (i) Within six months of an employee's first exposure to noise at or above a TWA of 85 dB, employers must establish for exposed employees a baseline audiograms against which subsequent audiograms can be compared. (ii) Where mobile test vans are used to meet the requirements of (g.5.i), the employer must obtain a valid baseline audiogram within one year. Where baseline audiograms are obtained over six months after employees first exposure at or above the action level, hearing protectors must be worn for the period exceeding six months. (iii) Testing to establish a baseline audiogram must be preceded by at least 14 hours without exposure to workplace noise. Hearing protectors may be used as a substitute for this requirement. (iv) Employers must notify employees of the need to avoid high levels of nonoccupational noise exposure during the 14 hours before audiometric testing.

(6) *Annual audiogram.* After establishing a baseline audiogram, the employer must obtain a new audiogram for each employee exposed at or above the action level at least annually.

(7) *Evaluation of audiogram.* (i) Each employee's annual audiogram must be compared to that employee's baseline audiogram to determine if the audiogram is valid and if a standard threshold shift as defined in paragraph (g.l0) has occurred. This comparison maybe done by a technician. (ii) If the comparison of the audiograms reveals a standard threshold shift, the employer may obtain a retest within 30 days and use the retest results at the annual audiogram. (iii) Problem audiograms must be reviewed by the audiologist, otolaryrngologist or physician to determine the need for further evaluation. The employer must provide this person with the following information: a copy of the requirements for hearing conservation; the baseline audiogram and most recent audiogram of the employer to be evaluated; measurements of background sound pressure levels in the audiometric test room as required is Appendix D; and records of audiometric calibrations required by (h.5).

(8) *Follow-up procedures.* (i) If a comparison of the annual audiogram to the baseline audiogram reveals a standard threshold shift as defined in (g.l0) the employee must be informed in writing within 21 days. (ii) Unless a physician determines that the shift is not caused or aggravated by Occupational noise exposure, the employer must ensure that: employees not using hearing protection are fitted with hearing protectors, trained in their use and care and required to use them; employees already using hearing protection are refitted and retrained and if necessary provided with more effective hearing 34

protection; the employee is referred for a clinical audiological evaluation or otological examination if additional testing is necessary or if the employer suspects that a medical pathology of the ear is caused or aggravated by wearing hearing protectors; or the employee is informed of the need for an otological examination if a medical pathology of the ear unrelated to the wearing of hearing protectors is suspected. (iii) If an employee exposed to less than an eight hour TWA of 90 dB reveals a standard threshold shift that is not persistent during subsequent audiometric testing, the employer must inform the employee of the audiometric testing results yet may discontinue hearing protector use requirements for that employee.

(9) Revised baseline. An annual audiogram may be substituted for the baseline audiogram under the following circumstances: (i) Where the standard threshold shift is persistent; or (li) Where the audiogram indicates significant hearing improvement over the baseline audiogram.

(10) Standard threshold shift

> (1) As used in this section, a standard threshold shift is a change in hearing threshold relative to the baseline audiogram of an average of 10 dB or more at 2000, 3000 and 4000 Hz in either ear.
>
> (2) In determining whether a standard threshold shift has occurred, allowance may be made for the contribution of aging to the change in hearing level by correcting the audiogram according to Appendix F.

(h) Audiometric test requirements.

(1) Audiometric tests must be pure tone, air conduction, hearing threshold examinations, with test frequencies including at a minimum 500, 1000, 2000, 3000, 4000 and 6000 slit. Tests at each frequency must be taken separately for each ear.

(2) Audiometric tests must be conducted with equipment that meets the specifications of, and is maintained and used in accordance with ANSI Specification for Audiometers, 53.61969.

(3) Pulsed-tone and self-recording audiometers must meet the requirements specified in Appendix C.

(4) Audiometric examinations must be administered in a room meeting the requirements listed in Appendix D.

(5) Audiometer calibration. (i) The functional operation of an audiometer must be checked before each day's use by testing a person with known, stable hearing thresholds, and by listening to the audiometer's output to

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make sure it is free from distorted or unwanted sounds. Deviations of 10 dB or more require an acoustic calibration. (ii) Audiometer calibration must be checked acoustically at least annually according to Appendix E. Test frequencies below 500 Hz and above 6000 Hz may be omitted from this check. Deviations of 15dB or more require an exhaustive calibration. (iii) An exhaustive calibration must be performed at least every two years according to the ANSI Specification for Audiometers, S3.6-1969. Test frequencies below 500Hz and above 6000 Hz may be omitted from this calibration.

(i) Hearing protectors.

(1) Employers must make hearing protectors available to all employees exposed to a TWA of 85 dB or greater at no cost to the employees. Hearing protectors must be replaced as necessary.

(2) Employers must ensure that hearing protectors are worn by all employees who: (i) Are required by paragraph (b.1) of this section to wear personal protective equipment; and (ii) Who are exposed to the action level and have either not yet had a baseline audiogram established or have experienced a standard threshold shift.

(3) Employees must be given the opportunity to select their bearing protectors from a variety of suitable hearing protectors provided by the employer.

(4) Employers must provide training in the use and care of all hearing protectors provided to employees.

(5) Employers must ensure proper initial fitting and supervise the correct use of all hearing protectors.

(j) Hearing protector attenuation.

(1) Employers must evaluate hearing protector attenuation for the specific noise environments in which the protector will be used by a method described in Appendix B.

(2) Hearing protectors must attenuate employee exposure at least to a TWA of 90 dB as required by (b).

(3) For employees who have experienced a standard threshold shift, hearing protectors must attenuate employee exposures to a TWA of 53 dB or below.

(4) The adequacy of hearing protector attenuation must be reevaluated whenever employee noise exposures increase to the extent that the hearing protectors provided may no longer provide adequate attenuation. Employers must then provide more effective hearing protectors where necessary.

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(k) Training program.

(1) Employers must institute a training program for all employees who are exposed to noise at or above a TWA of 55 dB, and must ensure employee participation in the program.

(2) The training program must be repeated annually for each employee included in the bearing conservation pro-gram. Information provided in the program must be up-dated to remain consistent with changes in protective equipment and work processes.

(3) Employers must ensure that each employee is informed of the following: (i) The effects of noise on hearing; (ii) The purpose of hearing protectors, the advantages, disadvantages and attenuation of various types and instruction on selection, fitting, use and care; and (iii) The purpose of audiometric testing and an explanation of test procedures.

(l) Access to information and training materials.

(l) Employers must make copies of this standard available to affected employees and also post a copy of it in the workplace.

(2) Employers must provide informational materials pertaining to this standard to affected employees; these materials are supplied to the employer by the Assistant Secretary.

(3) Employers must provide, upon request, all materials related to the employer's training and education program pertaining to this standard to the Assistant Secretary and the Director.

(m) Recordkeeping.

(1) *Exposure measurements.* Employers must maintain an accurate record of all employee exposure measurements required by (d).

(2) Audiometric tests. (i) Employers must keep all employee audiograms obtained according to (5)2 (ii) The record must include: the name the job classification of the employee; date of the audiogram; the examiner's name; date of the last acoustic or exhaustive calibration of the audiometer; the employee's most recent noise exposure assessment; and the employer must maintain accurate records of the measurements of the background sound pressure levels in audiometric test rooms. -

(3) *Record retention.* Employers must keep records required in (m) for at least the following periods: (i) noise exposure measurement records for two years; (ii) audiometric test records for the duration of the affected employee's employment.

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(4) *Access to records.* All records required by this section must be provided upon request to employees, former employees, representatives designated by the individual employee and the Assistant Secretary. The provisions of (1910.20 a~) and (5-i) apply to access to records here.

(5) Transfer of records. Employers who cease to run a business must transfer all records to the successive employer and the successive employer must maintain them as outlined in (m.3).

(n) Appendices.

(I) Appendices A, Ill, C, D and E are mandatory.

(2) Appendices F, G, H and I are informational and are not mandatory.

(o) Exemptions. Paragraphs (c) through (n) are not applicable to oil and gas well drilling and servicing operations.

(p) Startup dale. Baseline audiograms required by (g) must be completed by March 1, 1984.

Appendix A - *Noise Exposure Computation*

This Appendix explains how to compute an employee's noise exposure amount and how to convert dosimeter readings to an eight-hour TWA average sound level.

Appendix B - *Methods for Estimating the Adequacy of Hearing Protector Attenuation*

This Appendix describes several methods for determining the adequacy of hearing protection attenuation for employees who have experienced a standard threshold shift.

Appendix C - *Audiometric Measuring Instruments*

This Appendix sets guidelines for the capabilities and use of audiometers.

Appendix D - *Audiometric Test Rooms*

This Appendix consists of requirements for rooms used for audiometric testing.

Appendix E - *Acoustic Calibration of Audiometers*

Audiometer calibration must be checked acoustically at least annually according to the procedures described in this Appendix. Audiometers must be checked for sound pressure output, linearity and tolerances.

Appendix F - *Calculation and Application of Age Corrections to Audiograms*

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If an employer chooses to adjust the audiogram due to the contribution of aging to the change in hearing level the employer must follow the procedure described in Appendix F.

Appendix G - *Monitoring Noise Levels*

This Appendix gives information on noise monitoring equipment and procedures.

Appendix H - *Availability of Referenced Documents*

This Appendix provides a list of where employees may obtain referenced publications which have been incorporated into this standard.

Appendix I - *Definitions*

This Appendix consists of a list of the definitions which apply to terms found in this standard.

SPECIFIC REQUIREMENTS

Pulp, Paper & Paperboard Mills (1910,261)

(b.2) *Personal protective equipment.* Noise attenuation devices, foot protection, shin guards, hard hats, or other personal protective clothing and equipment must be worn when hazards warrant their use. All equipment must be maintained in accordance with applicable ANSI standards and mutt be cleaned and disinfected before being used by another employee. Ear protection must conform to ANSI standards.

(c.6.ti) Handling pulp chips from railway cars & (c.7.ii) Handling pulp chips from trucks. In addition to other personal safeguards, ear protection must be provided when the noise level may be harmful.

(e.8) *Barker feed.* Among other requirements, ear protection equipment must be worn by the operator and others nearby if there is any possibility the noise level may be harmful. See (1910.95) above.

Pulpwood Logging (1910.266)

(C.1.vi) Personal protective devices. Provide protection against the effects of noise exposure when sound levels exceed those of Table G-16 in (1910.95), measured on the A scale of a standard sound level meter at slow response.

Requirements from the Construction Standards

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Section (1926.52)- *Occupational Noise Exposure* -in the construction standards outlines the same limits for employee exposure to noise as the general industry standard above. Employers in the construction industry are also required to utilize feasible engineering and administrative controls as the primary means of reducing excessive sound levels. However, the specific requirements of the hearing conservation amendment (1910.95.c-n) do not apply to construction.

Where personal protective equipment is necessary, section (1926.101) - *Hearing Protection* - requires that ear protective devices inserted in the ear be individually fitted by competent persons. Plain cotton is not considered an acceptable protective device.

Requirements from the Maritime Standards

The Marine Terminals standard (1917) incorporates the entire General Industry hearing conservation rule (1910.95, above).

Section (1918.95)- *Longshoring Operations in the Vicinity of Repair & Maintenance Work* -is concerned with noise inasmuch. as it may interfere with safe work procedures.

(a) Longshoring must not be done where chipping or scaling of decks, bulkheads or sides of vessels creates excessive noise which interferes with communication of warnings or instructions.

Practice Room RATIOS *

Notes:

Our "EXPERT" table will give the music executive an idea of the appropriate size for specialized music education/performance rooms. It is very difficult to develop an adequate rule-of-thumb for the number of specialized music education/performance rooms needed to satisfy a particular program. However, most institutions seem to have at least one music classroom at 800-1000 square feet per 50 music majors (music classroom RATIO 1:50).

Most typical Music Practice Room RATIO per music major is 1:5 for Conservatories, RATIO 1:12-20 for most Schools/Colleges of Music. Quoting Budgetary Construction Costs is always dangerous. First of all, the $/S.F. method leaves much to be desired regarding accuracy (there are so many unknowns utilizing this method). However, it is an effective commencement point for establishing an initial project construction cost budget. The numbers contained in Illustration Numbers 97 and 98 pertain only to new construction costs and must be tempered by the music executive's perception of overall building quality (the higher your expectations for building quality = the greater the $SF) and the regional location of the facility (the cost of construction in major east and west coast cities is generally higher than the cost of construction in the midwest and the south).

In addition to a knowledge of anticipated music building Construction Costs, the informed Music Executive must also be aware of two (2) additional areas of significant project expense:

ANTICIPATED FIXTURES, FURNISHINGS AND EQUIPMENT (FF&E) COSTS:

The construction of a new music building by itself will accomplish little towards furthering a department/school's academic mission if an adequate budgetary line item has not been established for "outfitting" a new building project with a furniture and equipment needed to make it usable. Illustration No. 99 touches upon some of the FF&E costs which must be anticipated by an informed Music Executive:

- New Furniture
- Fixed and Moveable Performance Seating
- Millwork (shelving, countertops, cabinetry, storage units, etc.)
- Concessions/Kitchenette Moveable Appliances (refrigerators, dishwashers, ice makers, microwaves, etc.)
- Library Shelving and Equipment
- Photocopy Machines
- Recording Studio Equipment
- Student and University Instrument Storage Lockers
- Library Circulation and Building Security Desks

Performance Facility Terminology:

- Concert Hall
- Multi-purpose Auditorium
- Audience House
- Continental Seating
- Aisle/Traditional Seating
- Stage House
- Fly Loft
- Battens
- Arbors
- Counterweights
- Counterweight Rigging
- Winch/Electric Rigging
- Rigging
- Stage Grid/Grid iron
- Line sets
- Catwalks
- Up Stage/Down Stage
- Stage Left/Stage Right
- Proscenium Arch
- Trap(s)
- Orchestra Pit
- Pit Filler/Cover
- Orchestra Shell Towers
- Overheads/Ceiling
- Clouds
- Eyebrow
- Green Room
- House Control Room/Booth
- Backstage Lighting/Dimming controls
- Black Box/Studio Theatre
- Arena Theatre
- Thrust Stage
- Proscenium Stage