Young Composers' Tutorial:
Orchestration
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Strings

Violinists of the Philharmonia Orchestra in United Kingdom

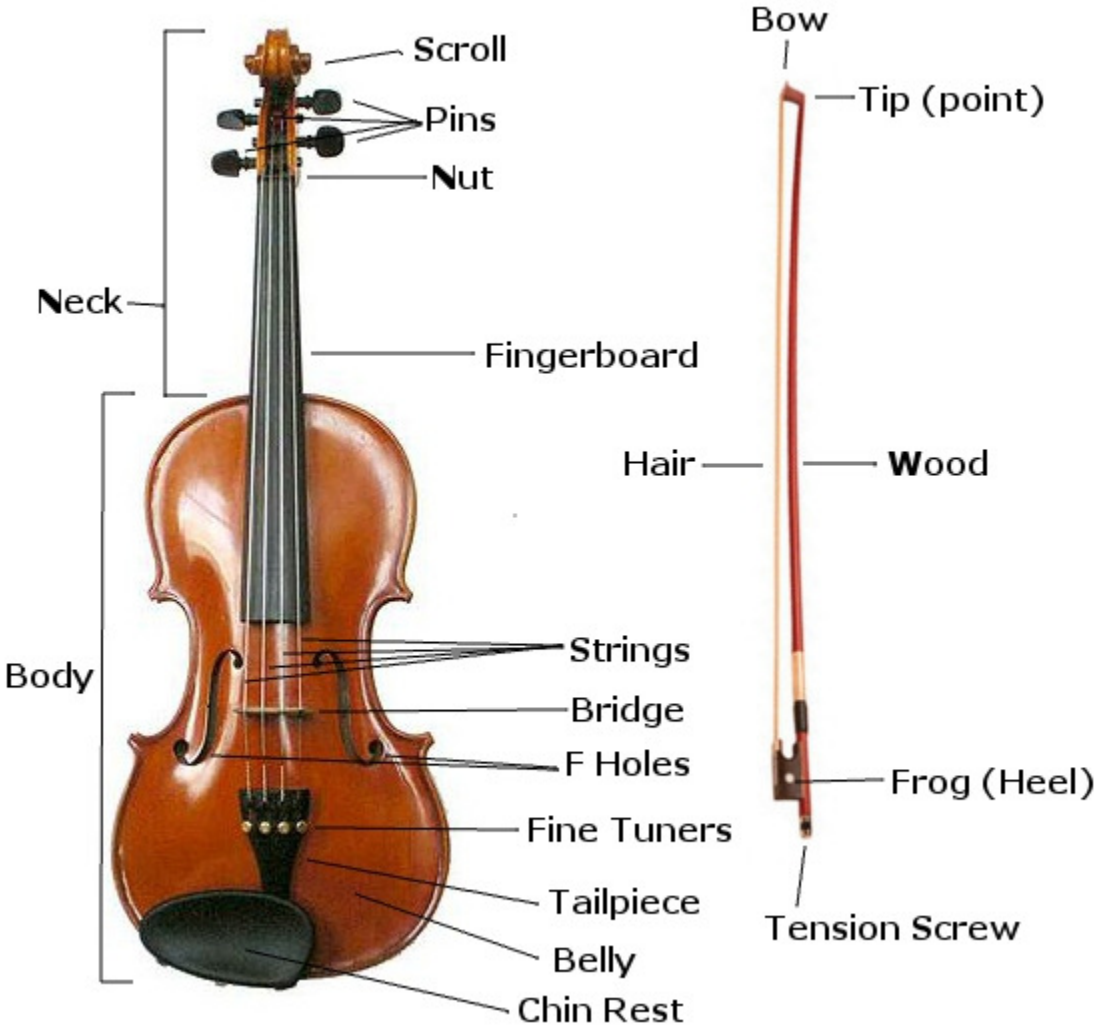
Stringed instruments, known by their technical name "chordophones," are instruments that produce sound by vibrating strings. The strings can be either "bowed", meaning a bow is drawn across the string like a violin, or "plucked", meaning the strings are directly manipulated via the fingers like a guitar. This produces two distinct groups of stringed instruments obviously named "bowed" and "plucked." We will begin with the bowed strings as they are, by far, the most important to the orchestra, and then move on to plucked in the second part.

Bowed Strings

Bowed stringed instruments are very important to the orchestra constituting the orchestra's largest section: usually, up to 70% of the players on stage are string players. The bowed strings descended from the *lira da braccio* of the Renaissance period. By the 1700s, the strings became the first orchestral family to be technically perfected thus being the first to be fully exploited by composers. As such, this historical weight necessitates that we spend a lot of time on the bowed strings; they are, in effect, the thrust of the orchestra.

The four major bowed string instruments shown approximately to scale

There are four major bowed stringed instruments in the orchestra: the violin, viola, violoncello, and double bass. They are in descending order of pitch and number in the orchestra. Note that strings are never used in the concert band save for the occasional double bass.



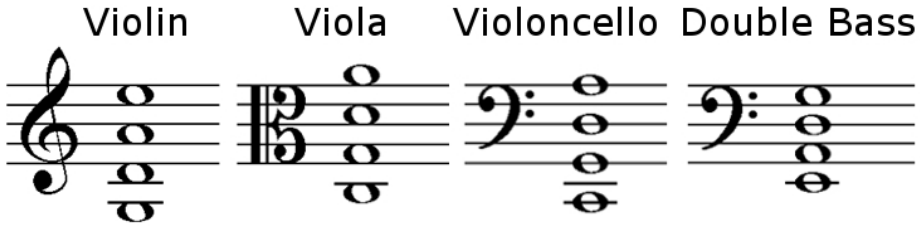
Anatomy of the bowed strings

In a nutshell, sound is created by drawing a bow across a string making the string vibrate. The pitch is controlled by the length of the string that is allowed to vibrate which is determined by the fingers; volume and intensity is determined by the pressure of the bow on the string; timbre is generally determined by the placement of the bow on the string.

To hold the instrument, the chin is held against the *chin rest* on the *body* while the left hand balances the instrument usually with the thumb underneath the *neck.* The playable part of the *string* is between the *nut* and the *bridge*. The fingers of the left hand press against the strings along the *fingerboard*. The left hand determines the pitch by shortening the string and can add vibrato by pressing firmly and slightly rocking the finger. The strings themselves are tuned by the *tuning pegs* on the end of the *neck* near the *scroll* and sometimes fine tuned with special pins (*fine tuners*) on the *tailpiece* which lies on the *belly*.

The right hand holds the *bow* at the *frog* end of the bow (also called the *heel*); the *tip* (also called the *point*) is the opposite end of the bow. The bow is placed on the string with the *hair* side down and then drawn across it to make sound. Depending on the angle of the bow certain strings can be played, even more than one at a time. The bow can be placed either between the fingerboard and bridge (which is the standard place), or on the fingerboard, or near (or on) the bridge. One can also forego the bow altogether and just pluck the strings with the fingers. Each technique gives a different timbre.

The different instruments all look similar in appearance except for their dimensions: the larger the instrument, the lower the range. The Violin, Viola, and Violoncello all have four strings that are tuned in fifths while the double bass has four* strings tuned in fourths. See their standard tuning below:

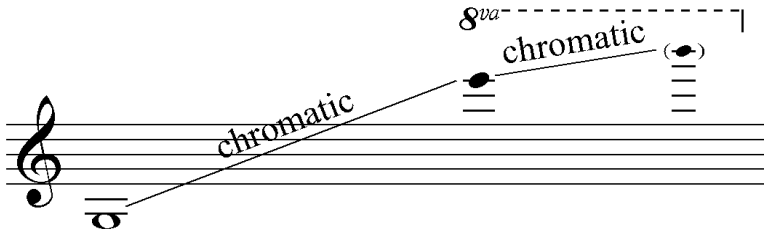


*The bass sometimes has a fifth string tuned to C^0 below the E^0 or the E string is sometimes tuned down to C^0 with the "C-extension." We will discuss these special cases later when dealing with the specifics of the Double Bass.

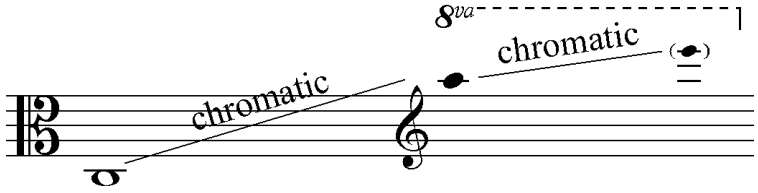
The ranges are limited by these strings: the lowest string is always the low-end limit to the range while the top string dictates the high-end limit. Pitches cannot go infinitely high because the fingerboard is only so long. A good rule is to assume two full octaves above the highest string as the limit in orchestral writing, though, in some cases, an additional fifth or more can be assumed depending on the case. However, that extra bit of range is very risky and of little use in orchestral section playing. Solo and chamber uses can use that range easily though.

Here are the general ranges for each of the instruments:

Violin:

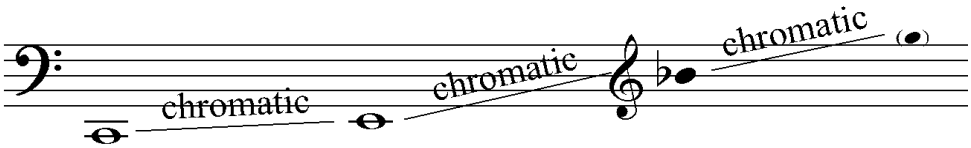


Viola:



Violoncello:

Double Bass:



We will discuss each range in greater detail later when talking about each individual instrument.

The String Section

The string section is the only section that is doubled in the orchestra. In other words, there is more than one player per part. The number of players on each part varies depending on the size of the orchestra. All the instruments are divided into five groups in the standard string section: Violin I, Violin II, Viola, Violoncello, and Double Bass. As the names imply, the five groups consist solely of one type of instrument each, i.e. "Violin I" has only Violins in it, "Double Bass" only "Double Basses" in it. The groups make the string section resemble a four-part SATB Choir (that is, Soprano, Alto, Tenor, and Bass) with an added Double Bass section. Because of the historical use of the Double Bass as part of the “basso continuo” in baroque music, it usually doubles the Violoncello line down an octave.

Obviously, however, music has progressed far beyond just SATB writing, so this historical rationale for the groups is largely moot: Double Bass parts are often very independent of the ‘Cellos. Or, for example, Violin I and II will often double at the octave breaking the rules of traditional SATB writing. No longer are the strict rules of the old classical school necessities, but rather just guidelines of a certain sound that can be broken at will. However, composers are excepted to still use the traditional five groups no matter how complex they are, such as in Ligeti’s *Atmosphères* where every instrument plays something different despite still be divided into the traditional 5 groups.

The players within each group in the string section play with two players per stand. One sits on the left side, the “inside” player, with another on the right, the “outside” player. The number of stands within each group varies depending on the availability of each instrument for certain groups. But the standardized symphony orchestra (followed by most modern professional orchestras around the world) uses this standard:

Violin I: 8 – 9 stands (16 – 18 players)
Violin II: 7 – 8 stands (14 – 16 players)
Viola: 5 – 6 stands (10 – 12 players)
Violoncello: 5 – 6 stands (10 – 12 players)
Double Bass: 4 – 5 stands (8 – 10 players)

Of course these numbers are not absolute and sometimes vary. For example, the New York Youth Symphony (the major youth orchestra for the New York City area and one of the top in the United States) has 10 stands of Violin I rather than 8 and only 3 stands of Basses at best. Some school orchestras may be lacking in violas completely or have an excess of violins. These variances have to do with the availability of the instruments; this doesn't usually apply to professional orchestras though who can hire musicians at will. Usually if the composer calls for a specific number of string players (as Strauss or Penderecki often did) they will be provided if the number requested is within a reasonable range of the guideline above.

A point should be made about the homogeneity of the strings. The strings have the most consistent sound between the entire ranges of the instruments. Accordingly, a melody can effortlessly flow between one group to another with little change in timbre. This is very advantageous to composers in orchestration and has been exploited many times over the history of the orchestra. A melody can also be doubled at the octave (or other interval) and have similar timbre throughout leading to a very "clean" and sometimes "rich" sound, similar to the organ effect of doubling ranks with similar ranks an octave up (8' doubled by 4').

Techniques of the Strings

Let us begin our discussion of *what* the strings can actually do. We already explored the most basic facts about how sound is produced. We will expand on that a bit now.

Bowing

The bow is drawn across the string in two ways, either from the frog to the tip, called a downbow, or from the tip to the frog, an upbow. Naturally the downbow and upbow nomenclature comes from the general direction of the bow from the perspective of the player. *Bowing* is the broad technique of *how* the bow is drawn across the string. Because the bow is so incredibly versatile, there is rarely a "correct" bowing for any particular passage of music. One should therefore know all the possibilities and sounds that the bow can produce and ask for certain techniques according to the composer's intentions.

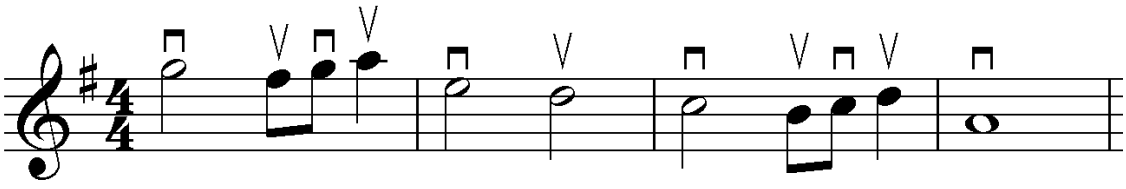
There are two symbols that you must memorize to indicate bowing in your scores.

Upbow:

Downbow:

These symbols are placed above the notes just like any standard articulation like so:

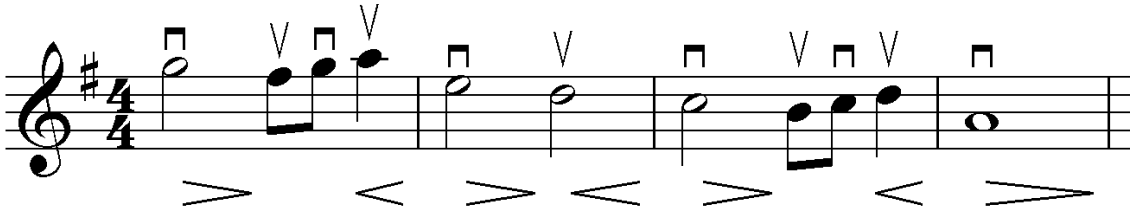
Elgar: Pomp and Circumstance March No. 1, Trio



This type of bowing is the most common type of bowing where downbows and upbows alternate. It is called *non-legato* bowing since it produces a very non-legato sound, i.e. every note is clearly separated because of the bow change. Players will always default to this type of playing if nothing else is indicated, i.e. notes with no other markings. Therefore, to indicate every bowing like in the example above is superfluous and should never be done. (The original has no bow markings.)

It is usually the concertmaster (that is, the section leader of the First Violins) that determines the bowing for the string section and they all follow a uniform bowing pattern of upbows and downbows as necessitated by the music. However, whether to use one or the other is up for debate and bowings can often be changed on a whim if the concertmaster or conductor wishes. One should also be aware that regardless of how specific composers' markings for bowing will be, they will often be rejected by the musicians for a more "correct" bowing that usually varies on their specific tastes. Thus, it is the most prudent to *only* specify bowing when specific sounds are needed.

Downbows have the potential for the greatest force because the frog (and thus hand) is closest to the string allowing for the greatest leverage on the bow. Downbow notes will *diminuendo* if played with a consistent force of the hand as the bow is drawn across the string because there is less and less leverage on the bow as the frog moves away from the string. With an upbow, it is the opposite: there is little leverage on the bow because the frog is far away from string and notes will *crescendo* when played with consistent pressure. This presents an odd peculiarity for the player and composer because passages usually do not intend to have those gradations of dynamic mid-phrase. If played with consistent pressure of the hand, the example from above would sound like this:



This cannot be good for expression! The player must compensate for this peculiarity by adjusting the force of the bow by the hand on the string to eliminate those changes of volume. Another consequence of this peculiarity is that *cresc.* notes will usually be played with upbows and *dim.* with downbows if possible. Composers should keep that in mind but not necessarily concern himself or herself too much. Good players, even mediocre ones, will correct these problems on their own.

In general, concertmasters and conductors will attempt to make strong beats fall on a downbow while pickups (anacrusis beats) and weak beats fall on upbows. This rule does not *always* apply, obviously dependent on context, but is the general default. However, composers can override that default by writing in bowing markings in the score that are "unusual" to get a specific sound. Consider this great example from Tchaikovsky:

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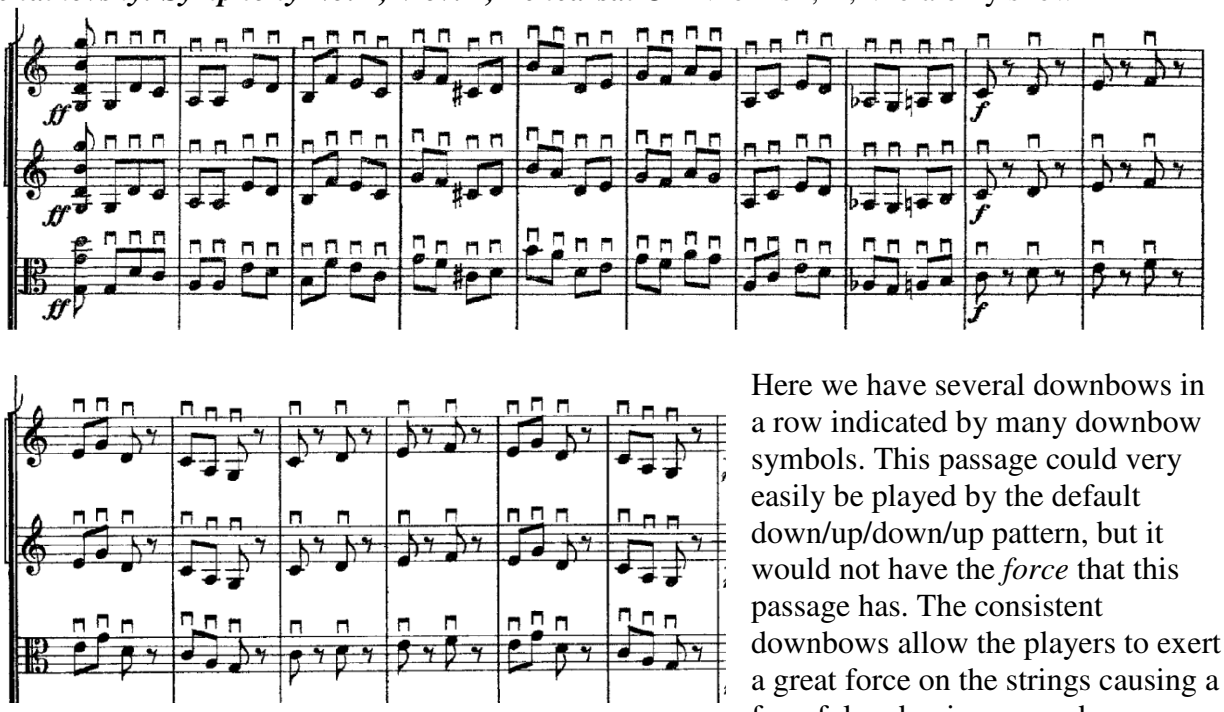
Tchaikovsky: Symphony No. 2, Mov. 4, Rehearsal C – Violins I, II, Viola only shown

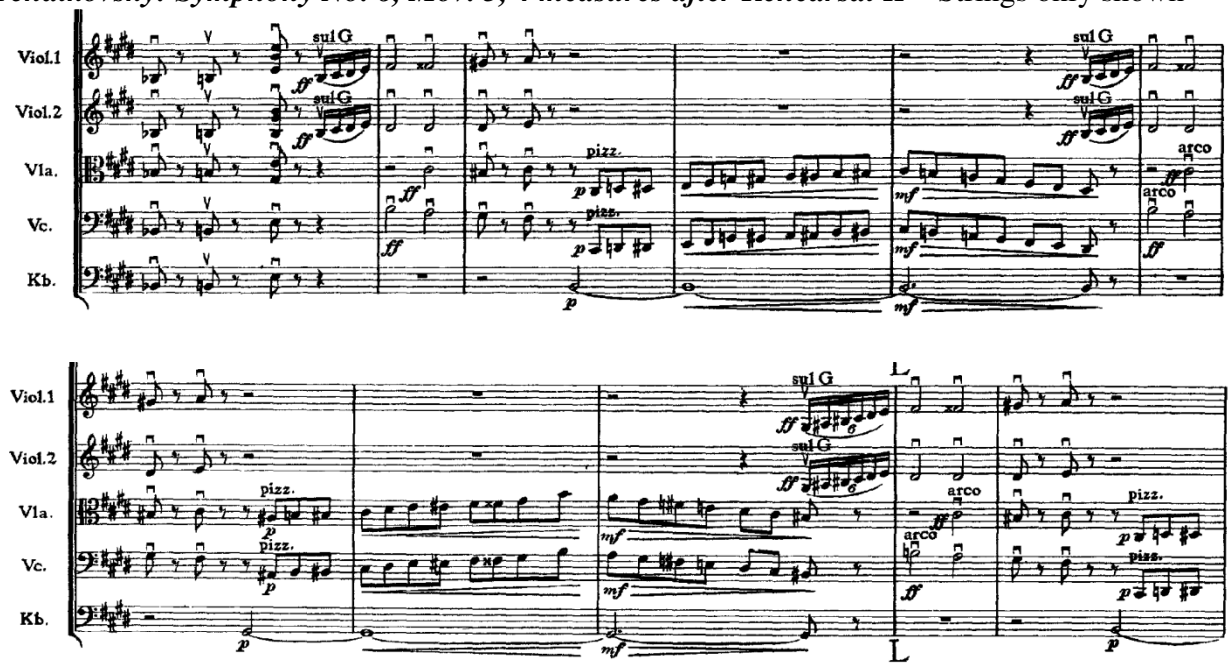


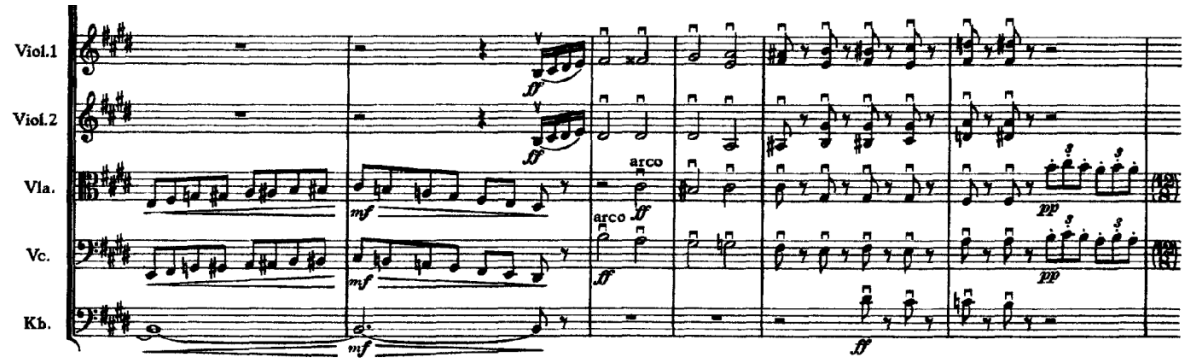
Here we have several downbows in a row indicated by many downbow symbols. This passage could very easily be played by the default down/up/down/up pattern, but it would not have the *force* that this passage has. The consistent downbows allow the players to exert a great force on the strings causing a forceful and unique sound.

Recording: Los Angeles Philharmonic, Zubin Mehta, conductor

Tchaikovsky also used this technique in his *Symphony No. 6, Mov. 3* where he used the strings to emphasize the accents of the strong beats in the march.

Tchaikovsky: Symphony No. 6, Mov. 3, 4 measures after Rehearsal K – Strings only shown





Recording: Los Angeles Philharmonic, Zubin Mehta, conductor

Both of these examples require the player to "retake" the bow after each stroke, or lift the bow slightly and move it upward so new leverage can be gained on the bow for a second downbow. Therefore, all consecutive downbows will inventively be separated, even more than the non-legato downbow/upbow pattern. This separation is very effective for marcato-like sounds just like Tchaikovsky used above.

Notice in the March (Symphony No. 6) Tchaikovsky indicates *sul G* for the violins, meaning "on the G string" which provides a much more intense timbre than the regular D and A strings which the passage would have been played on normally. We will discuss different strings with each individual instrument since it is different for each.

The use of consistent upbows is far less commonly marked by *composers* but often used by players in softer accompaniment passages. The effect is not as useful when compared to the consistent downbows, however, consistent upbows are used relatively commonly in *louré*-style bowing which we will discuss shortly.

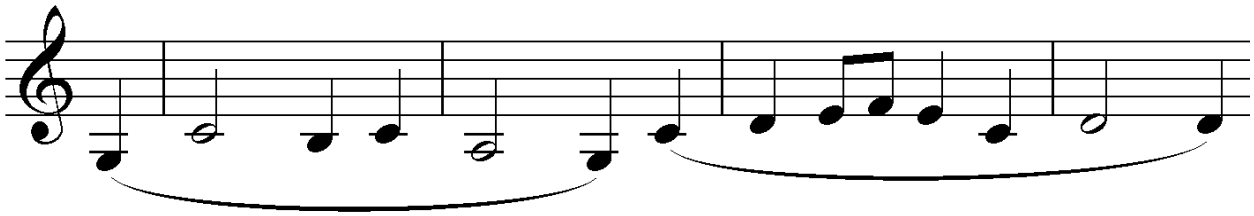
Slurs and Legato Bowing

In continuing with our discussion of bowing, we come to probably the most misunderstood marking in string music: the slur. Slurs, known as "those curvy line thingies", denote *bowing* in strings music: when more than one note is under a slur, those notes will be played in a single bow motion in the same direction. This is known as *legato* bowing allowing notes to be effortlessly connected with no break. Legato bowing is very popular with composers and leads to that typical rich and "romantic" sound that only the strings can provide.

While legato bowing is very useful, it presents a huge physical problem to the composer, specifically, the fact that the bow is not infinitely long. Only so many notes can be played legato and thus slurred together. To further complicate matters, the number of notes that *can* be played is completely dependent on context and even the instrument.

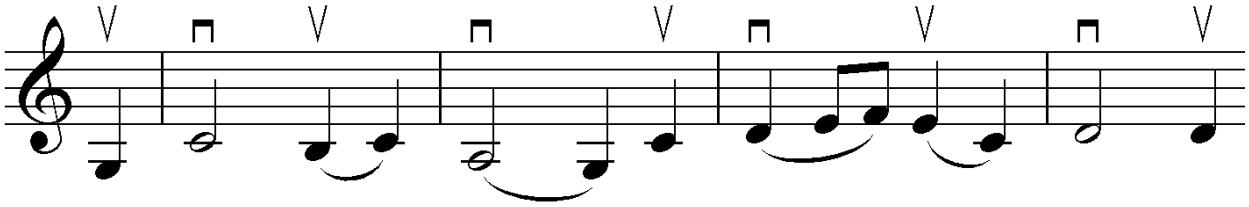
Unlike in piano music, the slur should *never* be used as a phrase marking. Long slurs indicating phrasing just confuse the player. It is better to let the music imply phrases, or, if necessary, use other notation to indicate phrases such as breath marks or dynamics or what have you. So long phrase markings like this:

Brahms: Symphony No. 1: Mov. 4 - Theme With Phrase Markings



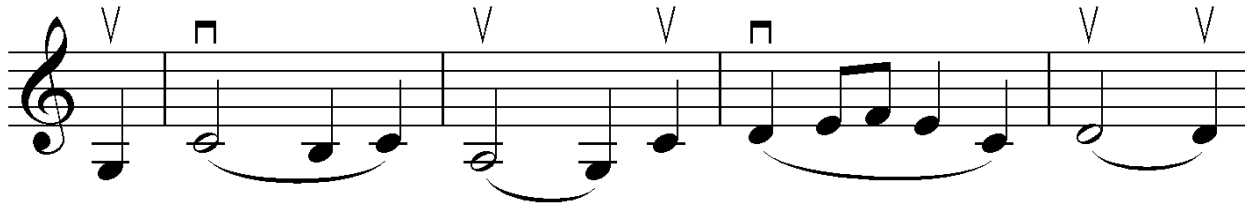
should never be written in a string part. As a better example, if the composer would want a legato sound, slurs could be written like so: (Bowing markings are written for clarity. They would not be present in the final part because bowing would be made obvious by the slurs.)

Alternate Brahms Example 1



Or one could also write this:

Alternate Brahms Example 2



Notice the use of the upbow on the anacrusis (pickup) to each two-bar phrase. This makes the first strong note (C^4 of phrase 1 and D^4 of phrase 2) receive a downbow and thus greater importance in the phrase. The difference between Examples 1 and 2 is whether to give importance to the cadence note (A^4 in phrase 1 and D^4 in phrase 2) by either splitting the slur on beat three, as in Example 1, or continuing the slur all the way through the bar, as in Example 2. In Example 1, the strong note and cadence note would be generally of equal importance. But in Example 2, the cadence note would be less important than the strong note.

Both alternate Examples 1 and 2 would be similar in sound (legato sound) and general expression, it is just a matter of preference to where natural dynamics should be implied. For the first example, the dynamics tend to rise and fall about every half note. In the second, they rise and fall every whole note. These subtle expressions are articulated with the change of bowings.

Now let's look at what Brahms actually wrote in context:

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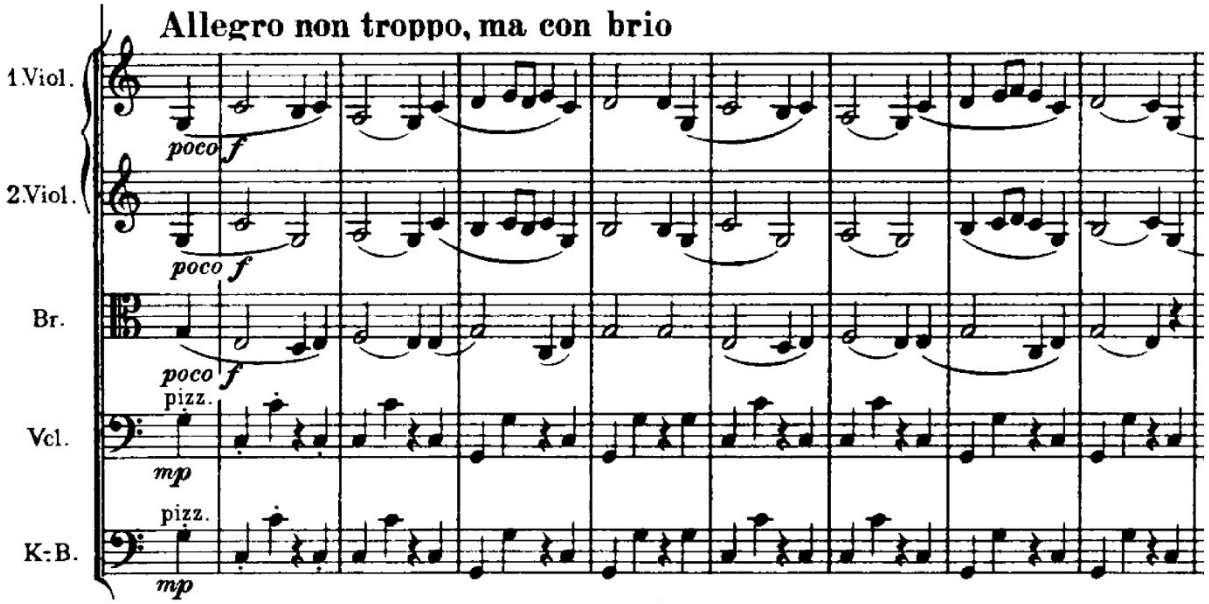
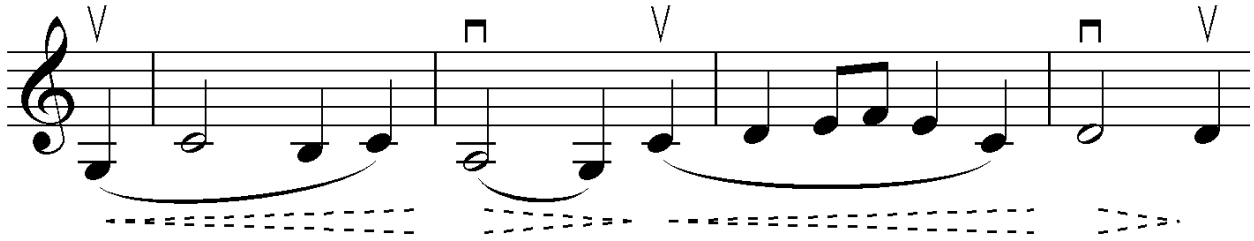
Brahms: Symphony No. 1: Mov. 4, First Statement of the Theme – strings only shown



Recording: Berlin Philharmonic, Simon Rattle, conductor

Here he takes our second example a step further. He forces the pickup to be placed within the initial bow. This leads to a bowing like so:



The dashed hairpins underneath the example show an approximation of the subtle natural dynamics in Brahms's example. The forced upbow on the strong beats allow for a longer crescendo that *leads* to the downbow on the cadence note at the end of each phrase. The first strong note is no longer strong but a continuation of the phrase. Notice too that he uses consistent slurs between the Violins and Viola who have the tune harmonized. This leads to a very homogenous sound with an expressive legato feel.

Could he have written in the hairpins? Probably, but the effect may have been too pronounced for his tastes; the page would also be quite cluttered with extra information when the dynamics would just follow the natural dynamic flow of the line. This melody is a very simple example on how effective slur usage can bring great expressiveness to the line with little actually written. Most of what is played by the player is actually "just understood" by musical practice. Brahms certainly could have been *more* specific, but in order to allow the players to "just play," he gives them just enough freedom to express themselves as a group. It is in subtle details like this where orchestration can truly shine.

As a disclaimer, this may be only *one* particular bowing used by any particular orchestra. Indeed, bowings of even the great masters are changed for a more "correct" bowing. Composer beware!

Legato Bowing Over Longer Sections
Let us now consider some more details into legato bowing. When playing soft the bow is not pressed as heavily on the strings as when playing loud. Accordingly less length of the bow is required to sound a note when playing soft as compared to loud. Likewise, when playing fast, more notes can be slurred because more notes exist per unit of time. Slower tempos require more bow because every note is longer. In slower tempos, slurs should be generally shorter than faster tempos.

In the Brahms example above, he used relatively long slurs because the tempo is relatively fast. If the tempo was even 20 or 30 beats per minute slower, the long slurs would not be as practical (though not impossible) at the forte dynamic he indicates. If the dynamic was piano, it *would* be possible at a slower tempo. As a general rule, one should assume that the slower and louder it gets, the more bow is necessary. Thus, shorter slurs are advised whenever the music gets loud and slow. The inverse is true for soft and fast, however one is not *required* to use long slurs at all; in that case it is only a matter of preference of where the legato bows should begin and end.

[Slurs long quiet Midsummer?]

[Slurs short and quiet]

[Slurs short and loud]

[Slurs long loud Tchaik?]

[Impossible slurs Liszt?]

Slurred Staccato
Legato bowing can sometimes be played staccato too. This may seem like a contradiction, but it is only in terms. When we speak of staccato for strings, we usually are referring to the “slurred staccato.” Notes are slurred and played in the same direction, but staccato dots indicate that the bow should separate those notes within that same direction. This concept of “slurred staccato” is used most commonly in accompaniments for strings. One of the most famous examples of “slurred staccato” comes from Handel’s *Messiah:*

Handel: Messiah: Tenor Aria, “Comfort Ye”
[score]

Slurred Tenuto or Louré
This type of bowing is a "plusing" of the legato when bowing in a common direction. This is related to slurred staccato except it is usually a "slurred tenuto"

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Articulations
As with all instruments, there are specific meanings for articulations for each individual string instrument. The table below shows a standard array of articulations and how the string player would be required to execute them with the bow. If necessary, we will also discuss BLARGMOSNTER!!!

Symbol	Name	Effect	Bow use	Downbow or Upbow?	Notes
	Staccato				
	Staccatissimo				
	Tenuto				
	Staccato-tenuto				
	Accent				
	Marcato				
	Marcatissimo				
	Tenuto-Marcato				
	Staccato-Marcato				
	Others?				

Jeté
Simply put, the "jeté" is when the bow will bounce off the string causing a ricochet effect. This effect is very common in solo string literature and is most often seen in the orchestra as solo string parts within the orchestra. This is mostly because the effect cannot be easily heard with a full string section; it would sound muddied if played by the whole group. Sometimes this is the intention, but this is usually in an accompaniment where a "woosh" of sound is wanted.

Examples:
[Blarg]

Double Stops

Examples:
Stravinsky: *Rite of Spring, Part 2*
Strauss: *Also Sprach Zarathustra*, solo violin

Tremolo
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Sul ponticello
Apart from bowing in the normal place of between the bridge and fingerboard, a string player can also play on the fingerboard and near (or directly on) the bridge. This produces a very different timbre. "Sul ponticello" is the Italian term for playing near (or on) the bridge. This effect changes the timbre by allowing many of the upper harmonics of the string sound to be

heard giving a harsh and metallic sound. This technique is often overused in horror film scores when combined with tremolo. Harmonics can also be played sul ponticello giving a very unique sound that is rare in the orchestral repertoire. Generally, all the normal effects playable with normal bowing are possible sul ponticello, however, many of those effects would sound harsh and unpleasant so the composer should keep that in mind. If one wants intense and harsh sounds sul ponticello is an effective way to get them.

Examples:

Giaccino: Medal of Honor Allied Assault Score!
Others

Sul tasto

The other bowing position is on the fingerboard. This term is "sul tasto," again an Itallian term. This effect gives a much softer and subtle effect than normal bowing, similar to a glassy flute-like texture, which is why the term "flautando" is sometimes used instead of sul tasto; both mean the same thing. Sul tasto is most effective in very soft to medium soft dynamics since the timbre does not have as much carrying power as the typical bowing sound. Harmonics are also very effective being played sul tasto giving to an even more ethereal sound than just harmonics alone. Keep in mind that very high notes will be impossible sul tasto because of the bow occupying up space on the fingerboard.

Examples:

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Col lengo

Probably the most underappreciated effect with the strings is "col lengo" which means to play with the wood of the bow. The string player will flip the bow over and literally play the strings with the wood side as if it was the hair side. This effect is very percussive and used to great effect when a soft percussive effect is needed, such as in the Holst example below. The bow will often bounce off the string added a quasi-jeté feel too it in faster tempos which is not readily reproduced on typical percussion instruments giving it a unique and subtle timbre.

Examples:

Holst: The Planets, Mars

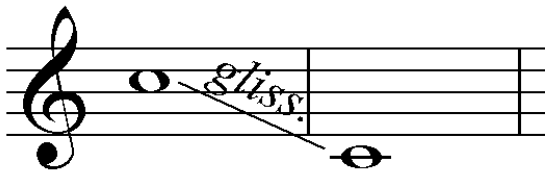
Glissando/Portamento

The strings are a few of the instruments capable of a true glissando. String players can glissando by sliding their finger along the string down (or up) the fingerboard making a continuous change of pitch. This effect is very effective for heavy expression of melodies with large gaps, often as a human voice would be forced to glissando.

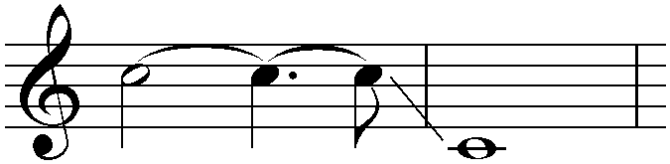
The subtler version of this, portamento, is intended as a natural connection of notes by siding between them. However, portamento is largely just "understood" and rarely marked by composers. A string player will almost always add *some* portamento between pitches simply with the passage marked *esspressivo* or similar.

The issue with glissandos is their wide variety and variables. The composer should be meticulous about how to notate the glissando. Should the glissando be through the whole bar or the end of the bar? Should it be a subtle shift between notes or a full on slide? Unfortunately, there are no real standardized notations for these differences and often infers from composers' styles and tendencies in past pieces, which, in most of young composers' cases, is impossible.

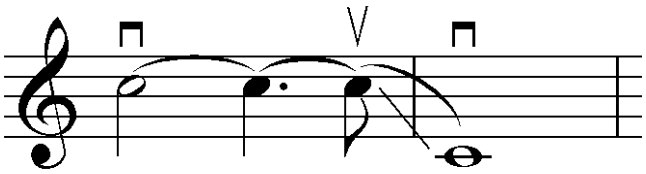
There are [blarg] elements of the glissando that must be clarified for the player: the duration of the notes being glissed, *where* the notes should be glissed, and the severity of the gliss. Here's an example of a gliss that is poorly notated:



We know that the first note (C^5) is a full four beats long and the second note (C^4) is a full four beats long. So the first condition has been satisfied. However, *where* does the gliss begin? The notation would imply that a full four-bar gliss would be wanted. But, say, the composer only wanted a sudden shift on the last 8th note on the top C^5. How would one notate that? The best way would be like so:



This clearly indicates that the C^5 should be held constant for 3 ½ beats before sliding down to the C^4. What about severity? Say this was a subtle expressive slide? Then there are two options. Either write in words *espressivo* or *subtle* etc., or draw a slur over the notes being slurred. However, this may come into conflict with bowing patterns. Some players will play it like this:



They would break the tie imperceptibly to make the slur sound more natural on an upbow. This is one of those exceptions to the slur rules where the slur means "legato" rather than bowing. The problem with this method is its obvious confusion of slurs and wouldn't be recommended. If all else fails, write what you want in a footnote in the score and parts in the language native to the orchestra performing. This will make it absolutely clear to them with no ambiguity.

Pizzicato

Up until now we have been discussing bowed string sounds. Sometimes, the composer will forego the bow altogether and ask the player to pluck the strings, much like a guitar or lute. This effect is called "pizzicato" from the Italian meaning "plucked." There are many flavors of the

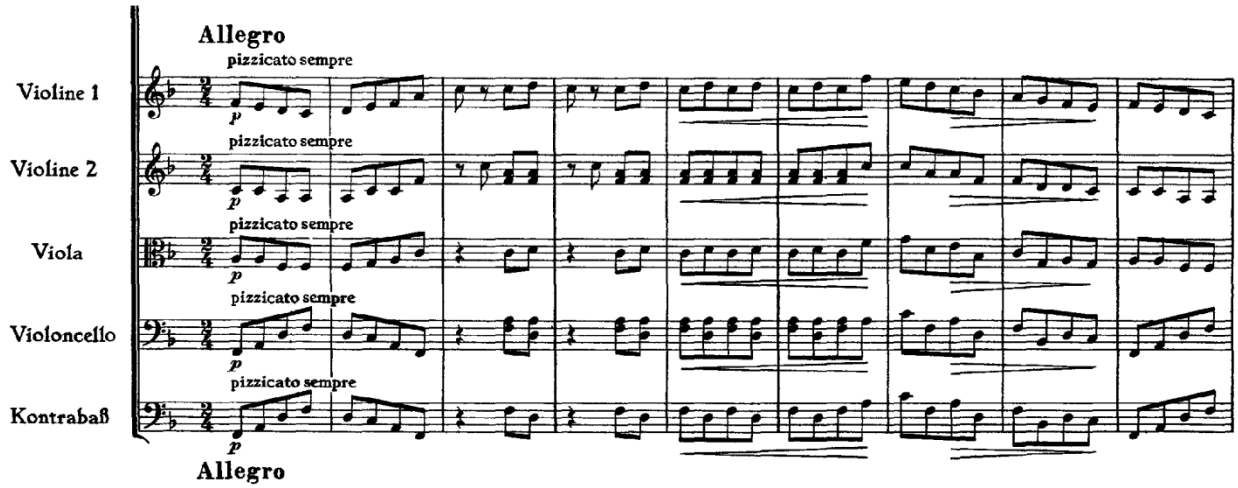
pizzicato and all are useful to the composer to provide an additional percussive sound to the orchestra.

The normal pizzicato method is to hold the bow still in the right hand and plucking with the free fingers. This is, by far, the most common method where short amounts of pizz. music are required. One can quickly switch to the bow very quickly because it is still being in the player's hand offering great versatility to switching between plucked and bowed sounds. Note too that a player will put the bow aside if the section of music has no bowed music in it for a great period of time. The composer can indicate "put bow aside" in the score if desired, but this is usually not necessary; it will be very obvious if there's enough music to justify putting the bow down. If the composer *does* indicate to put the bow aside (or writes a passage where it becomes required by sheer fatigue), make sure to leave extra time to pick up the bow.

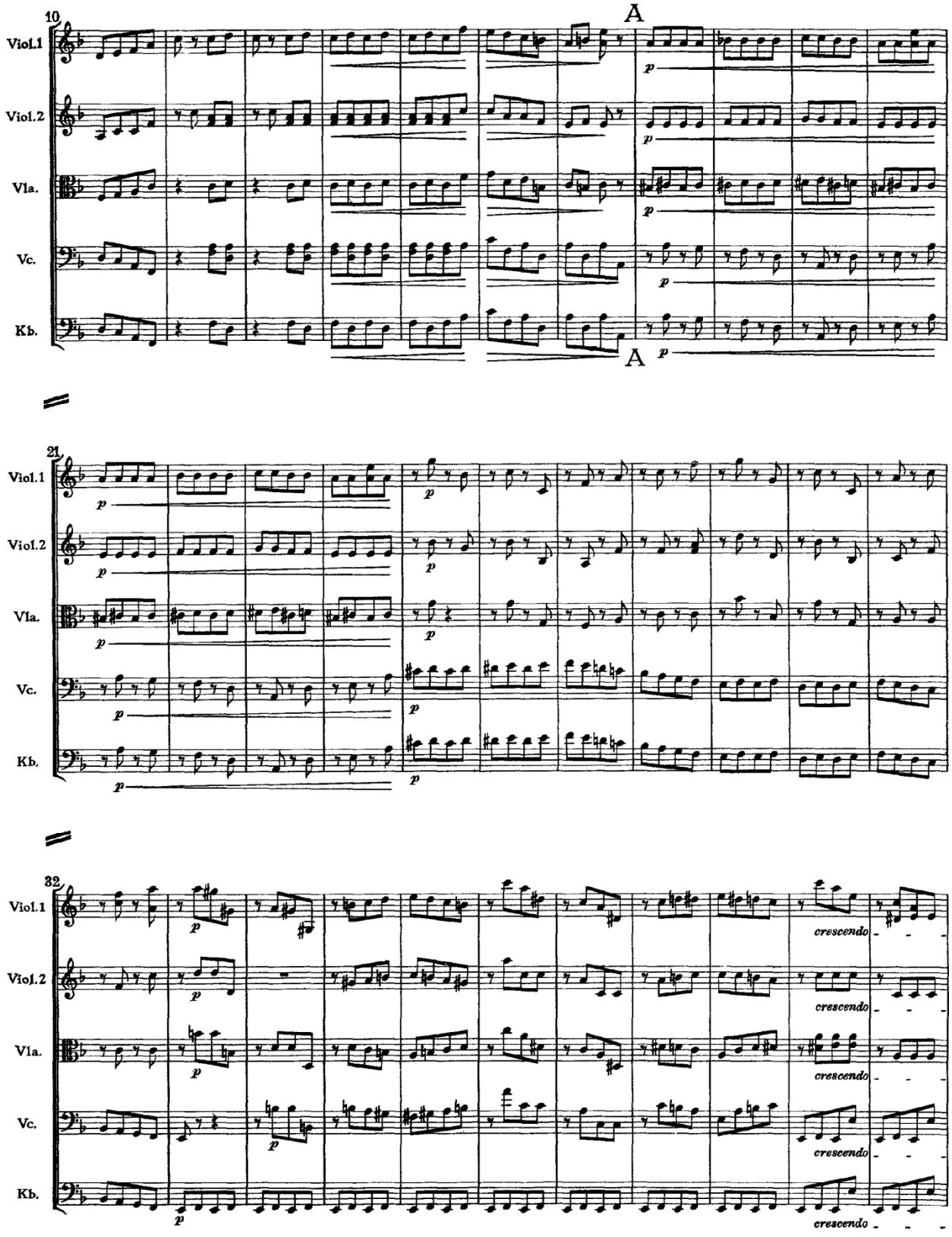
When the composer wishes to have a plucked sound, the score must contain the text "pizz." (above the staff in no italics). The player will then play any preceding music pizzicato even if there are large gaps in between them. (This is a similar scheme for mutes which we will discuss shortly.) Likewise, when the composer wishes a bowed sound again, the score must contain the word "arco" (above the staff in no italics) meaning "bowed." (Literally, it should be "col arco" meaning "with bow" but the col was dropped for brevity by as early as the Baroque era.)

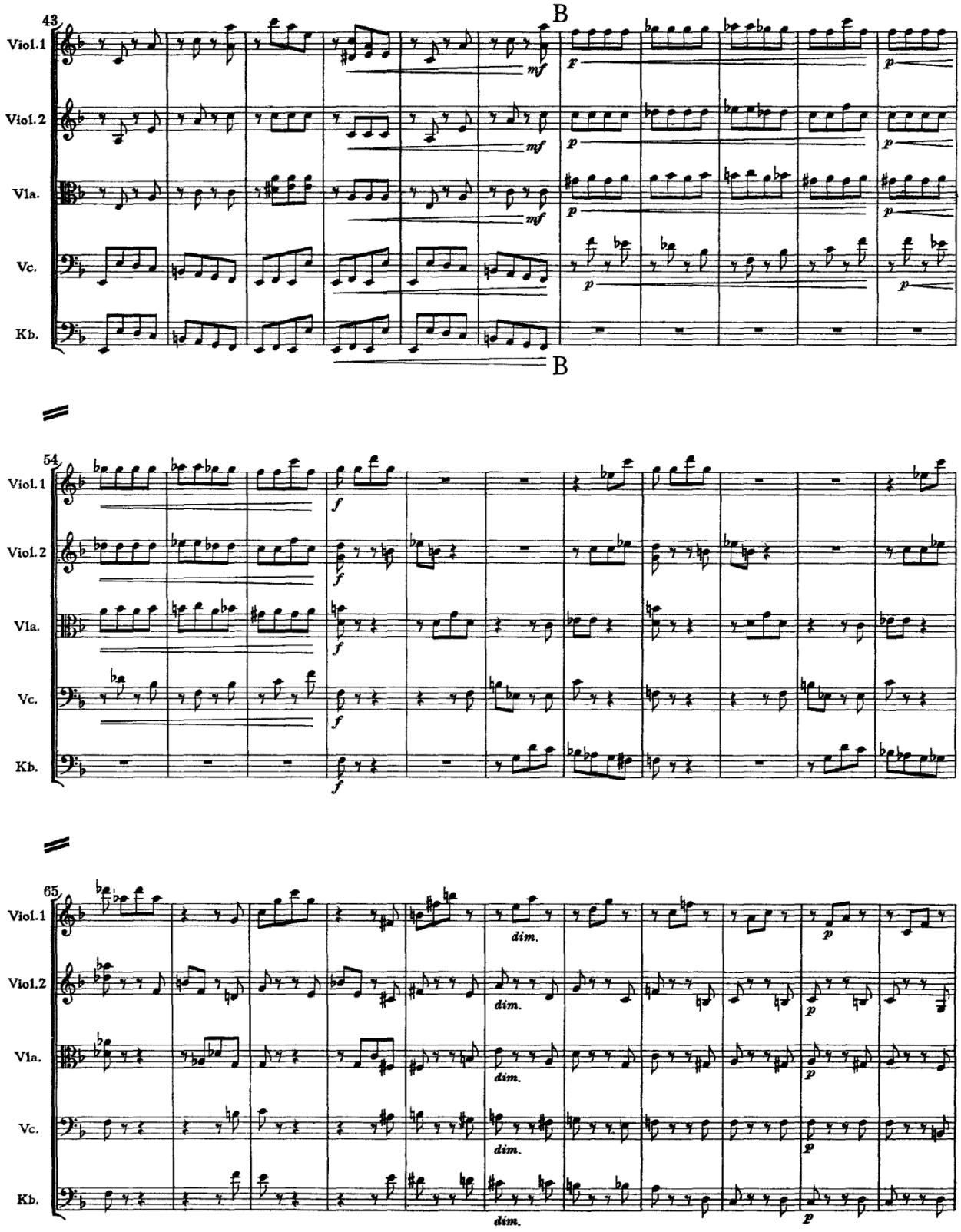
This standard pizzicato was used to great affect by Tchaikovsky in his *Symphony No. 4* where the third movement has the strings play completely in pizzicato. The third movement, sometimes nicknamed "Pizzacato ostinato," uses the strings in cleverly divided parts to allow a very dance-like and "happy" feel. One could have played this spiccato or staccato, but it wouldn't have the same buoyancy that it does. It also gives a refreshing change of timbre as the first and second movements were very arco dominated furthering its contrast to the second movement, a slow and mournful adagio. Be sure to listen to the entire symphony as a whole to see how the sudden change to pizzicato gives a great contrast to the darker first two movements and a development to the bombastic fourth movement.

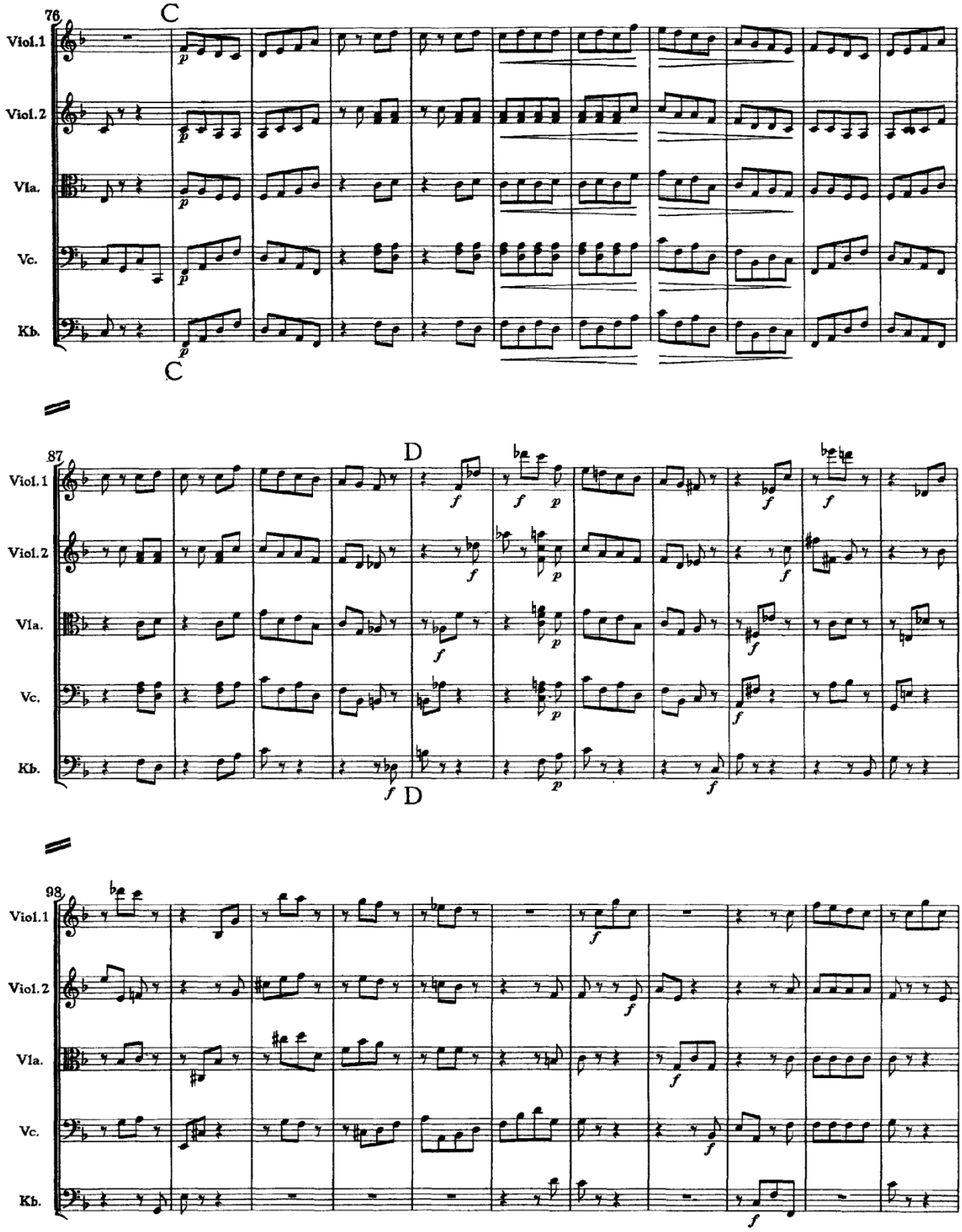
Tchaikovsky: Symphony No. 4, Mov. 3

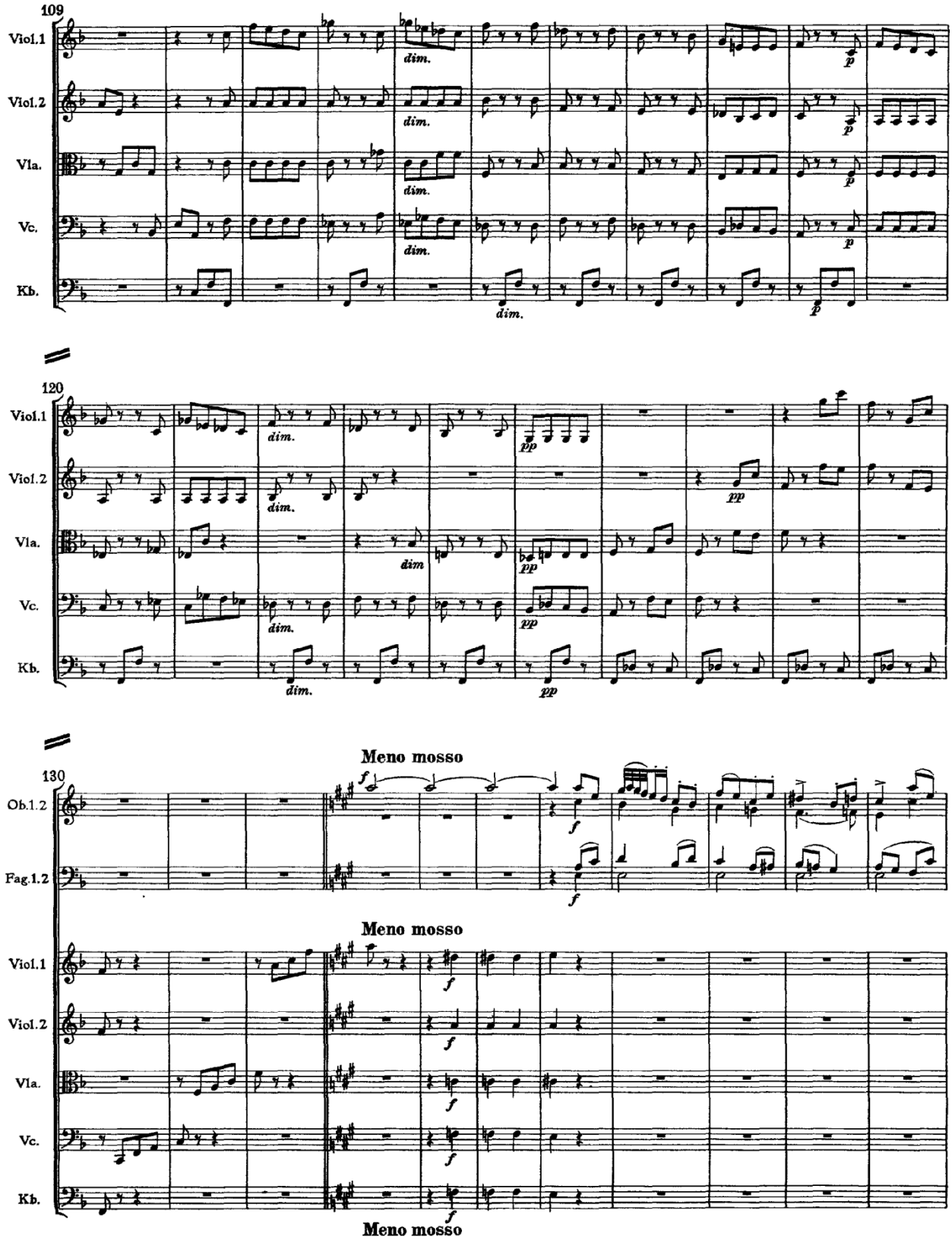


Recording: Los Angeles Philharmonic, Zubin Mehta, conductor


10
A
Viol.1
Viol.2
Vla.
Vc.
Kb.
p
A
21
32
crescendo


43
B
Viol.1
Viol.2
Vla.
Vc.
Kb.
mf
p
B
54
f
65
dim.


76
C
Viol.1
Viol.2
Vla.
Vc.
Kb.
C
87
D
Viol.1
Viol.2
Vla.
Vc.
Kb.
D
98
Viol.1
Viol.2
Vla.
Vc.
Kb.


109
Viol.1
Viol.2
Vla.
Vc.
Kb.
dim.
p
120
pp
dim
Meno mosso
130
Ob.1.2
Fag.1.2
f

Another great example of pizzicato is in [blargmonster] where [blarg blargy blarg].

Another flavor of pizzicato is the so-called "Bartok Pizz." named after Bela Bartok, the Hungarian composer of the early 20th Century. Bartok "invented" a new pizz. effect where the player snaps the string against the fingerboard. This leads of a very harsh pizzicato and is much more percussive than the regular pizz. This effect, while novel, is nothing new; it can be traced back to as early as Franz Biber in his strings suite *La Batallia* (1673) where he asks the basses to play pizzicato but in such a way that the snap the strings against the fingerboard to simulate cannon shots.

Biber: *La Batallia: Battle*

In a more modern example, [blarg] asks for a Bartok Pizz. [blarg

[Example blarg]

Note that the snap pizzicato requires great force on the strings and cannot be played quietly. Note too that the preparation (literally grasping the string) takes far longer than a regular pizzicato so it cannot be played with great speed; often the snap will be only used for one major note in a passage to emphasize something, similar to a percussion instrument. The snap pizz. is also difficult to execute on certain strings that are very tight, such as the E string of the Violin or the A of the Viola. A harsh normal pizzicato would have a very similar effect even though it does not "snap" against the fingerboard. To indicate a snap pizzicato note, the symbol should be placed as an articulation.

A further flavor of pizz. related to the Bartok Pizz. is the fingernail pizzicato. This version probably has the longest preparation time. The player is required to grasp the string with their fingernail and then pluck it. It is a rare effect on its own but virtually unheard of in the orchestra since the difference between it and the Bartok Pizz is too subtle to hear in a full string section. To indicate fingernail pizz. a small crescent (similar to a fingernail) will be placed above the note. This notation is not standard and should be explained in the score.

The final pizzicato flavor actually uses the left hand. This is most difficult technically and usually only used in solo string settings. Essentially, while the player is playing a note normally, another note is being plucked by the left hand *while* fingering the others. Obviously this is very hard to pull off effectively and thus is a rare effect outside of some specialized solo and chamber literature. The notation is to put a small plus sign above the note (same as "stopped" or "closed" in horns and percussion respectively). This effect, like fingernail pizz., is very rare and often not worth the trouble in orchestras because of all the multiple players available for divisi that could produce the same sound much easier.

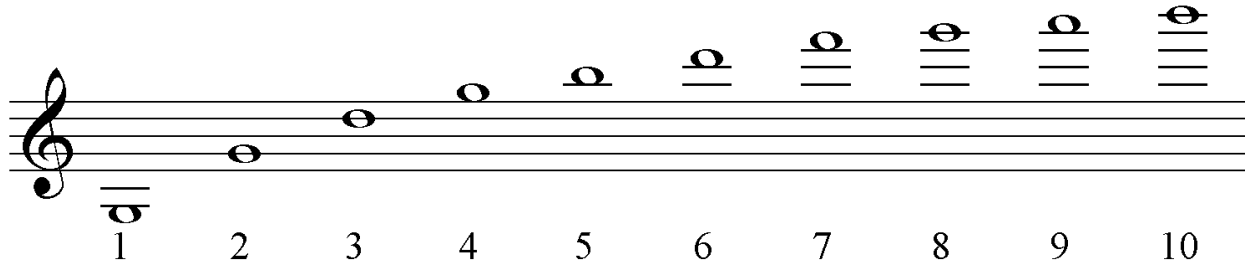
Harmonics

So far, we have been discussing bowed sounds where the left hand fingers press down on the strings all the way allowing for a full rich sound from the strings. What we have not discussed is *harmonics* which is produced by allowing the string to vibrate at a certain harmonic within the

harmonic series. This timbre is very soft and sweet. Harmonics can also be played extremely high, even out of range of human hearing, thus providing a very useful range extension for the strings.

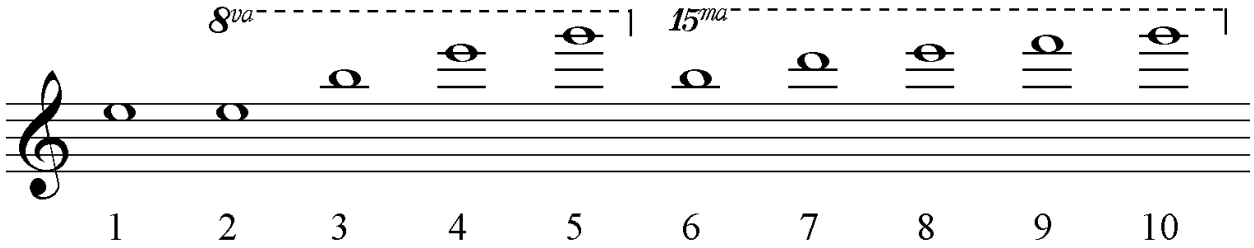
Harmonics are produced by touching the string (with the left hand) at certain points called *nodes* and then bowing the string. The left hand only touches the string but does *not* press the string down to the fingerboard allowing the whole string to vibrate. When no node is pressed, i.e. in regular bowing, the open string produces the fundamental of the harmonic series which is always the note that any particular string is tuned to; the G string produces a G^3 fundamental. As more different nodes are pressed, different harmonics along the series are produced causing the sound to change even though the entire string vibrates.

The harmonic series for the G string is as follows:



The numbers indicate the number of the harmonic, or *partials*. For example, G^4 (ladled with the number 2) would be the *second partial* of the G string while the D^6 would be the *sixth partial* of the G string. Note that there is (theoretically) no end to the harmonic series. The intervals will progressively get smaller and smaller the more partials there are. This becomes an issue with brass instruments since their entire mechanism is based on the harmonic series. Be sure to commit the concept of the harmonic series to memory because you will be using it often as an orchestrator.

The harmonic series can also be transposed to any fundamental; every note (or indeed frequency) has the same harmonic series (as in the same series of intervals), just with a different fundamental. For illustration purposes, here is the harmonic series for the E string:



As you can see, the E string harmonic series goes beyond the range of the piano and almost out of the human range of hearing.

However, there are limitations on harmonics, most notably dynamics and speed. Harmonics are very delicate and can rarely be played above a *p*, *maybe* at *mp*. They are also very hard to produce under some instances and we will discuss specifics for each instrument in turn; some instruments produce harmonics more readily than others; even some *strings* produce harmonics

better than others. Because of the tricky production of harmonics they can't be played with great speed. Indeed, some of the most effective uses of harmonics are slow melodies or long notes and chords being held out to emphasize the timbre. Needless to say, there are many factors in harmonics and they need to be taken on a case-by-case basis.

There are two types of harmonics: *natural* harmonics and *artificial* harmonics. Natural harmonics are produced by touching the node of an open string allowing a harmonic to sound. Artificial harmonics are produced similarly by touching the node of a stopped string, i.e. a new fundamental for the string in question. The combination of the two allows for a vast array of notes to be played via harmonics giving the composer great freedom to use this great sound.

Producing Harmonics

Harmonics follow the harmonic series by touching a node at a particular fraction of the sounding string. A simple way to figure out the fraction is to put the number of the partial in the denominator and put a 1 in the numerator. So, to make a harmonic to sound the second partial (the G^4 on the G string), one would touch exactly 1/2 way from the nut to the bridge; for the third partial, 1/3 from the nut to the bridge and so forth. Note too that any multiple factors of the first interval can also be touched to play the same harmonic. So for the third partial, one could touch either 1/3 of the way from the nut or 2/3 of the way from the nut; both will produce the same pitch. *However*, some of these "alternate harmonics" are not as reliable as others especially in a large orchestral context. Thus, we will usually only concern ourselves with the first and second (or very rarely a third) nodes per partial when discussing harmonics.

This system, while a bit confusing at first, is a very efficient way of figuring out what notes are possible with what harmonics. To illustrate this concept of fractions, see this picture:

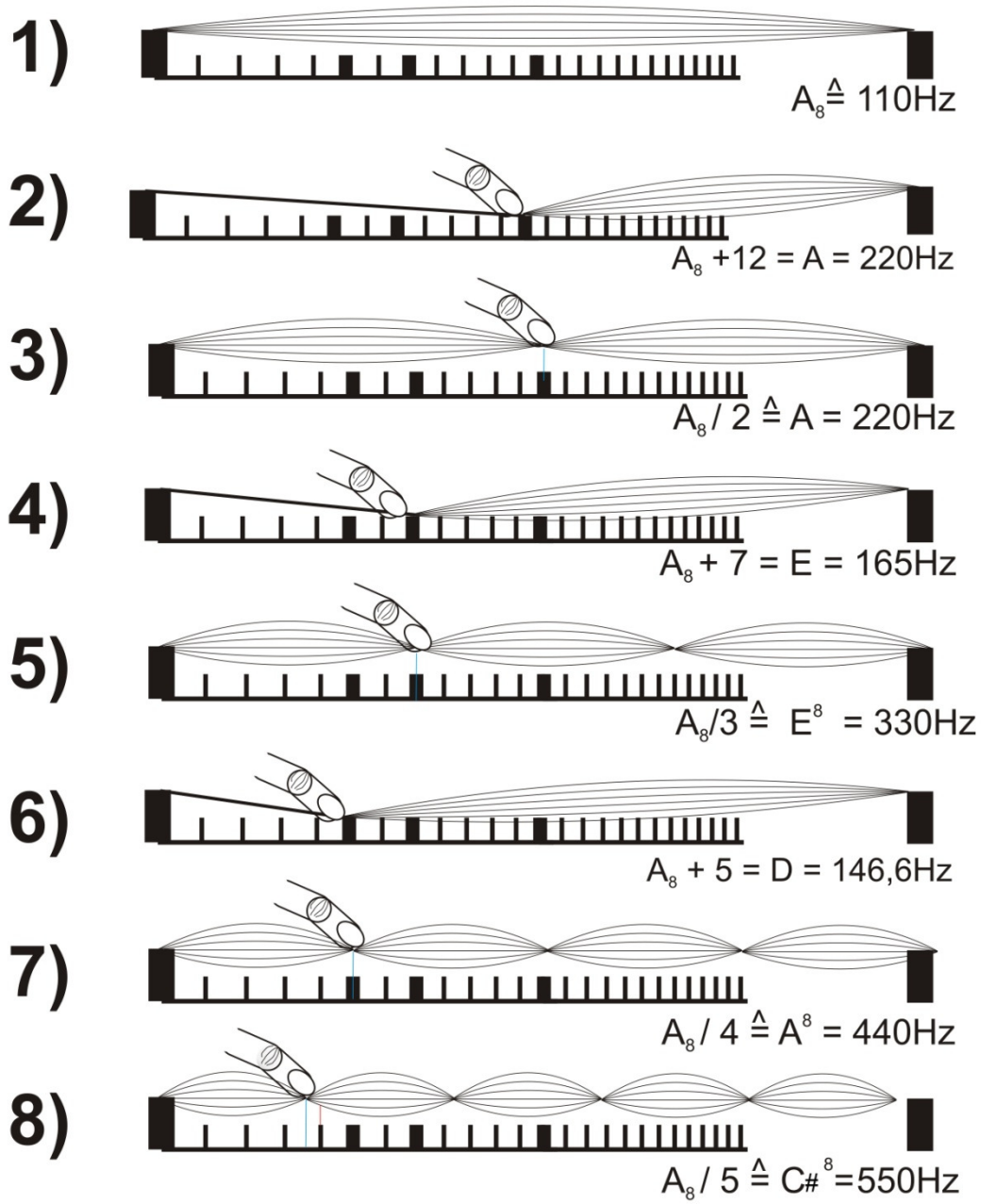


Image courtesy of user "Mjchael" of Wikimedia Commons

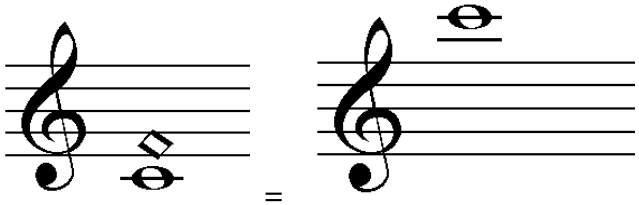
1) The fundamental A string. (This case would be a bass A string since it is 110 Hz or A^2)
2) Pressing the note at the ½ way point creates a note an octave up.
3) Touching the node at the ½ way point creates a harmonic an octave up.
4) Pressing the note at the 1/3 way point creates a note a fifth up.
5) Touching the note at the 1/3 way point creates a harmonic a fifth and octave (15th) up.
6) Pressing the note at the ¼ way point creates a note a fourth up.
7) Touching the note at the ¼ way point creates a harmonic two octaves up (15ma).
8) Touching the note at the 1/5 way point creates a harmonic a two octaves and a major third up (15ma + M3).

In examples 5, 7, and 8, the finger could also touch any of those points where the string vibrations cross to produce the same note. However, they won't be as effective, especially the more vibrations there are. (It is less efficient to make a note vibrate in 8 parts if the 5/8ths node is touched as opposed to the 1/8th node because the 5/8 must be divided into 5 and 3 parts to sound and that will not happen automatically.) As a general rule, the closer the finger is to the nut, the more reliable that node is as opposed to its factors.

Artificial harmonics are the same as natural harmonics in production.

Harmonics Notation

Probably the most confusing part of harmonics is how to notate them. Because of the different types of harmonics, it varies depending on context; the best way to is to use *diamond notation*. This notation uses a diamond shaped note head to indicate the touched note, the place where the node is touched to produce a harmonic.



Here we have a middle C (C^4) with an F above touched. This would be a "touch fourth" harmonic that we discussed above. It would produce a C^6, the C two octaves above the stopped note C^4.

Examples:

Mahler: *Symphony No. 1, Mov. 1,* opening for harmonics

A. Scodatura
   1. Examples:
      a) Mahler: *Symphony No. 4, Mov. 2*
      b) Saint-Saens: *Danse Macabre*

B. Extended Techniques (suggestions?)

Violin

II. Examples:
   A. Others

Viola

III. Examples:
   A. Others

Violoncello (Cello)

IV. Examples:
   A. Rossini: *William Tell Overture, opening*

B. Mahler: *Symphony No. 1, Mov. 1, cello solis*
C. Others

Double Bass

D. Examples:
E. Mahler: *Symphony No. 1*
F. Saint-Saens: *Carnival of the Animals: Elephant*
G. Others

Orchestrating for Strings

Of all the instrument families, the strings are probably the easiest and most versatile. By easiest I mean the least room for error. Following a few simple rules about orchestration for strings can make almost any music sound good for strings.

a) General Strings Examples:
(1) Mahler: *Symphony No. 3, Mov. 6*
(2) Mahler: *Symphony No. 5, Mov. 4*
(3) Mahler: *Symphony No.9, Mov. 4*
(4) Strauss: *Also Sprach Zarathustra*, middle part
(5) Shostakovich: *Symphony No. 10,* opening
(6) Stravinsky: *Firebird*, throughout
(7) Stravinsky: *Rite of Spring*, throughout
(8) Brahms: *Sympony No. 1, Mov. 2*, opening
(9) Bach: *Brandenburg Concerto No. 3*, triple sections
(10) Bach: *Brandenburg Concerto No. 4*, solo violin
(11) Others

Plucked Strings

Harp

1. Pedals
2. Rolled or blocked?
3. Specific notation
4. Glissando
5. Bisbiglando
6. Examples:
    a. Debussy: *Prelude on the Afternoon of a Faun: harp glissando*
    b. Ravel: *Daphnis et Chloe Suite No. 2, harp glissandos*
    c. Holst: *The Planets: Neptune, bisbiglando*
    d. Others

b) Guitar ???
c) Mandolin ???
(1) Examples:
(a) Mahler: *Symphony No. 7, Movs. 2, 4*

(b) Mahler: *Symphony No. 8*