

Chord theory

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1 Introduction

This document is my attempt to write the brief introduction to music theory I wish I had. I try to motivate from first principles why music has the structure it has and what the palette of options are.

The initial goal is to introduce the concept of a mode in music theory, and to focus on the major and minor modes as examples. The final target is to introduce chord progressions. What does it take to make a song?

2 Modes

In *diatonic* music there are seven notes in a scale before coming to the *octave* which has double the frequency of the original root note.

Example C-major and A-minor scales are:



where 1 and 2 denote that a note is a half step (1 semitone) or a whole step (2 semitones) above the previous note.

The sequence 2212221 defines the *major mode*. The major mode notes naturally occur on the white keys of a piano (no accents) in the key of C major (*i.e.* when C is the root). The sequence 2122122 defines the *minor mode*. The minor mode notes naturally occur on the white keys in the key of A minor. There are seven modes in total in diatonic music that all use the same seven notes, just starting from different positions for the root note.

Table 1: All the diatonic modes in 12-tone music.

Mode	Interval pattern	Root for all white	Notes for C root	Character
Ionian (major)	2212221	C	C D E F G A B	Bright, happy
Dorian	2122212	D	C D E \flat F G A B \flat	Minor, raised 6th
Phrygian	1222122	E	C D \flat E \flat F G A \flat B \flat	Dark, Spanish sound
Lydian	2221221	F	C D E F \sharp G A B	Dreamy, raised 4th
Mixolydian	2212212	G	C D E F G A B \flat	Major, flat 7th
Aeolian (minor)	2122122	A	C D E \flat F G A \flat B \flat	Sad, melancholic
Locrian	1221222	B	C D \flat E \flat F G \flat A \flat B \flat	Unstable, diminished

Western music tends to focus on using the major and minor modes, but there are exceptions.

3 Intervals

Now we introduce *polyphony*, playing more than one note at a time. An *interval* is the gap in pitch (frequency) between two notes. Each interval has a name as listed in Table 2. We will use notes of different intervals together to build chords.



Table 2: All the two-note intervals in 12-tone music.

Semitones	Interval	Freq ratio (just)	Freq ratio (equal temp)	Error
1	Minor second (m2)	$16:15 \approx 1.067$	$2^{1/12} \approx 1.060$	-0.007
2	Major second (M2)	$9:8 = 1.125$	$2^{2/12} \approx 1.123$	-0.003
3	Minor third (m3)	$6:5 = 1.200$	$2^{3/12} \approx 1.189$	-0.011
4	Major third (M3)	$5:4 = 1.250$	$2^{4/12} \approx 1.260$	+0.010
5	Perfect fourth (P4)	$4:3 \approx 1.333$	$2^{5/12} \approx 1.335$	+0.002
6	Tritone (A4/d5)	$45:32 \approx 1.406$	$2^{6/12} \approx 1.414$	+0.008
7	Perfect fifth (P5)	$3:2 = 1.500$	$2^{7/12} \approx 1.498$	-0.002
8	Minor sixth (m6)	$8:5 = 1.600$	$2^{8/12} \approx 1.587$	-0.013
9	Major sixth (M6)	$5:3 \approx 1.667$	$2^{9/12} \approx 1.682$	+0.015
10	Minor seventh (m7)	$16:9 \approx 1.778$	$2^{10/12} \approx 1.782$	+0.004
11	Major seventh (M7)	$15:8 = 1.875$	$2^{11/12} \approx 1.888$	+0.013
12	Octave (P8)	$2:1 = 2.000$	$2^{12/12} = 2.000$	0.000

The tritone is an augmented fourth or a diminished fifth (A4/d5), also called the “devil’s interval”. It is sometimes defined as 45:32 or 64:45 or $\sqrt{2}:1$. The minor seventh is sometimes defined as 16:9 or 9:5.

That certain intervals have simple mathematical ratios for the ratios of their frequencies is a rough start at the answer to: Why does music sound like that? Why certain tunings? Why 12 in 12-tone music?

In *just intonation* (or *pure tuning*), intervals use simple integer frequency ratios like 3:2 for a perfect fifth. These ratios produce the most consonant, pure-sounding intervals because the overtones align perfectly.¹ However, just intonation creates problems when changing keys or playing complex harmony.

Equal temperament solves this by dividing the octave into 12 equal semitones, where each semitone has a frequency ratio of $2^{1/12} \approx 1.0595$. This means a perfect fifth has a ratio of $2^{7/12} \approx 1.4983$ instead of exactly $3:2 = 1.5$. While equal temperament makes most intervals slightly out of tune compared to their pure versions, it allows music to be played in any key with the same relative tuning, making it the standard tuning system for Western music since the 18th century.²

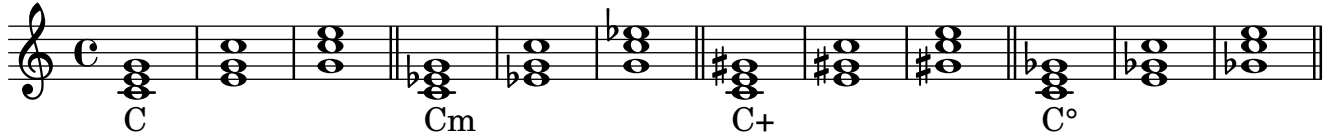
¹Versions of just intonation where understood in ancient Greece, attributed to Pythagoras and later to Eratosthenes.

²Twelve-tone equal temperament (TET) was first formalized by Zhu Zaiyu in China in 1584, and independently by Simon Stevin in the Netherlands in 1585 or some years later.

One can motivate why 12 is a nice number of semitones in an octave because it is arguably the coarsest equal division where both the 4th ($2^{5/12} \approx 4/3$) and the 5th ($2^{7/12} \approx 3/2$) are approximations that are acceptably close to pure for the average human ear.

4 Trichords

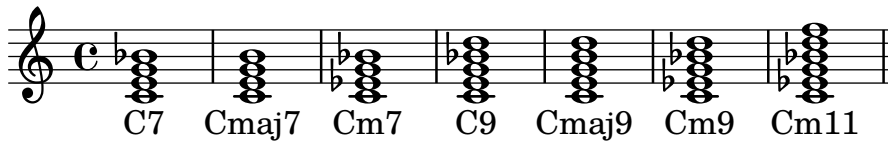
The scaffolding on which we will build chords are trichords, consisting of scale degrees 1-3-5 (root, third, fifth). The minor or major quality of the chord is determined by the 3rd interval being major or minor. Here are C-major and C-minor chords, and their first and second inversions, derived by rotating the bottom note to an octave higher. Following that are augmented (Caug or C+) and diminished (Cdim or C°) versions of a C chord, where the 5th is raised or lowered a half step, respectively.



5 Seventh chords and beyond

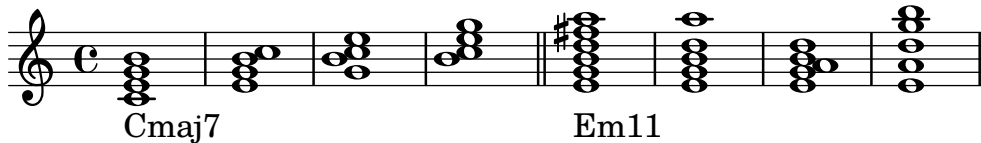
Adding a fourth note to a trichord creates richer, more complex harmonies. The most common extension is adding a 7th above the root.

A dominant seventh chord (C7) is a major trichord with an additional minor 7th interval added. A major seventh chord (CM7 or Cmaj7) is a major trichord with an additional major 7th interval added. A minor seventh chord (Cm7) is a minor trichord with an additional minor 7th interval added. There exist augmented and diminished versions of seventh chords that raise/lower the 5th and/or the 7th intervals.



Extensions can continue beyond the 7th to create 9th, 11th, and 13th chords, which are common in jazz.

These are Cmaj7 and its inversions, followed by variants of Em11:



6 Diatonic chords

Now we have introduced enough topics to ask a natural question:

If one wants to stay within a certain key in given mode, what chords are allowed?

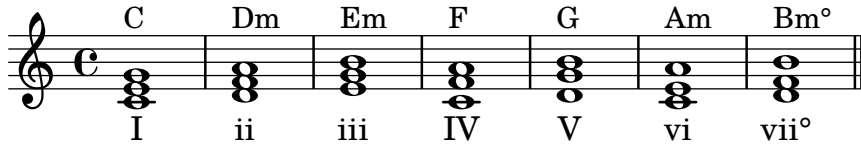
We will use roman numeral notation where major chords are written in capital letters and minor chords are written in lowercase letters. Roman numerals are used so the musician may understand the chord progressions regardless of the key they are played in.

For the major and minor modes, the answer turns out to be

Major: I ii iii IV V vi vii°
Minor: i ii° III iv v VI VII

To step through why this is the case, consider the C-major key as an example. The 1st trichord is clearly a C-major chord: C-E-G. The 2nd trichord beginning with D as the root is D-F-A, where note that since D-F

is a minor 3rd this trichord is minor. Therefore the second chord in the key of C major is Dm. The third chord is E-G-B, which is Em, and so on. One can tell which notes are allowed in each chord by remembering that we always pick only from the white piano keys in the key of C major.



The chords that are allowed naturally in each mode are summarized in Table 3.

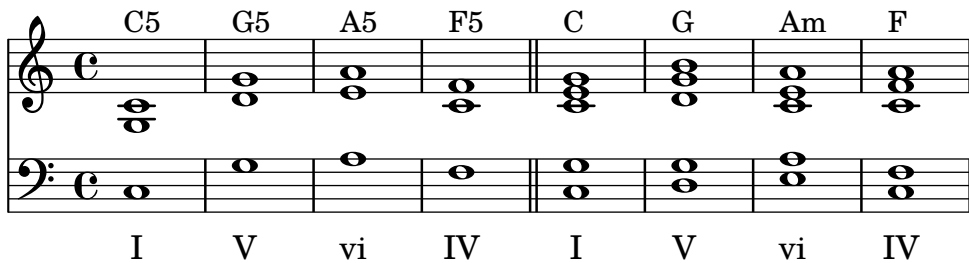
Table 3: Diatonic chords: chords that are natural for each mode.

Mode \ Chord	1	2	3	4	5	6	7
Ionian (major)	I	ii	iii	IV	V	vi	vii°
Aeolian (minor)	i	ii°	III	iv	v	VI	VII
Dorian	i	ii	III	IV	v	vi°	VII
Phrygian	i	II	III	iv	v°	VI	vii
Lydian	I	II	iii	iv°	V	vi	vii
Mixolydian	I	ii	iii°	IV	v	vi	VII
Locrian	i°	II	iii	iv	V	VI	vii

7 Chord progressions

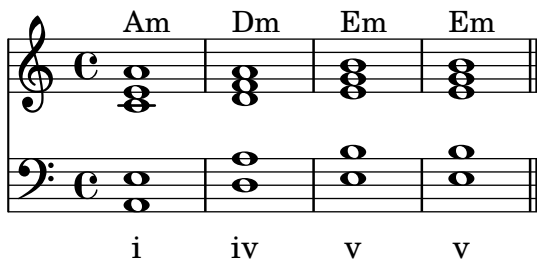
Note that the major chords that are allowed in a major mode key are I, IV, and V. Many pop songs have been written that utilize or focus on only these chords, perhaps throwing in a vi chord.

One of the most common chord progressions in Western pop music is I-V-vi-IV, sometimes called the pop-punk progression:



Here we have written it twice, the first time using *power chords*, which are commonly played on guitar in rock music. A power chord is a simplified trichord that does not include a 3rd interval, but includes a perfect 5th and an octave. In the second progression, we have included the 3rd intervals in the chords.

A common progression in the minor mode is the minor three-chord progression:



TODO: More/better examples.

Common chord progressions in Western pop music are listed in Table 4 and Table 5.

Table 4: Common chord progressions in Western pop music in major keys.

Name	Progression	Example in C major	Notable songs / Description
Pop-punk progression	I-V-vi-IV	C-G-Am-F	“Let It Be”, “Don’t Stop Believin”, “Someone Like You”, “Glycerine”, “What’s My Age Again?”
’50s, doo-wop progression	I-vi-IV-V	C-Am-F-G	“Stand By Me”, “Blue Moon”, “Every Breath You Take”
Three-chord rock	I-IV-V	C-F-G	“La Bamba”, “Twist and Shout”, “Wild Thing”
Rock ballad	vi-V-IV-V	Am-G-F-G	Common in rock music
Alternative progression	vi-IV-I-V	Am-F-C-G	“Zombie”, “Apologize”
Blues turnaround	V-IV-I	G-F-C	Blues standard turnaround
Eight-bar blues	I-V-IV-IV-I-V-I-V	C-G-F-F-C-G-C-G	“Key to the Highway”
Twelve-bar blues	I-I-I-I-IV-IV-I-I-V-IV-I-V	C-C-C-C-F-F-C-C-G-F-C-G	Boogie-woogie blues
14-bar hymn	I-IV-I-I-V-V-I-I-IV-I-I-V-I-I	C-F-C-C-G-G-C-C-F-C-C-G-C-C	“Amazing Grace”
14-bar folk song	I-IV-I-I-ii-V-V7-I-IV-I-IV-I-V-I	C-F-C-C-D-G-G7-C-F-C-F-C-G-C	“I’ve Been Working on the Railroad”, “The Eyes of Texas”
Jazz turnaround	ii-V-I	Dm-G-C	Jazz standard turnaround
Circle progression	I-vi-ii-V	C-Am-Dm-G	“Heart and Soul”, “Blue Moon”
Singer-songwriter	I-IV-vi-V	C-F-Am-G	“Self Esteem”, “What’s Up”
Canon progression	I-V-vi-iii-IV-I-IV-V	C-G-Am-Em-F-C-F-G	“Pachelbel’s Canon” progression
Mixolydian vamp	I-VII ^b -IV	C-B ^b -F	“Sweet Child O’ Mine”, modal mixture

Table 5: Common chord progressions in Western pop music in minor keys.

Name	Progression	Example in A minor	Notable songs / Description
Aeolian vamp	i-VI-III-VII	Am-F-C-G	“All Along the Watchtower”, “Stairway to Heaven” intro
Minor three-chord	i-iv-v	Am-Dm-Em	“Summertime”, basic minor progression
Andalusian cadence	i-VI-VII	Am-F-G	“House of the Rising Sun”
Descending minor	i-VII-VI-V	Am-G-F-E	Descending progression, common in minor keys

8 Modal progressions

Breaking the constraints of relying heavily on just the major and minor modes is a movement called *modal music*.

Simplified sample from “So What” by Miles Davis and Bill Evans:



Part of the beauty of the voicing of Evan’s chords is that he builds them by stacking perfect 4ths and then adding a major 3rd on top. That makes a Em11 chord that includes a 7th and a 11th (4th), but drops the 9th (2nd). A focus on building chords from 4ths instead of 3rds and 5ths is called *quartal harmony* and it results in chords that sound harmonically ambiguous.