TEE-Classics

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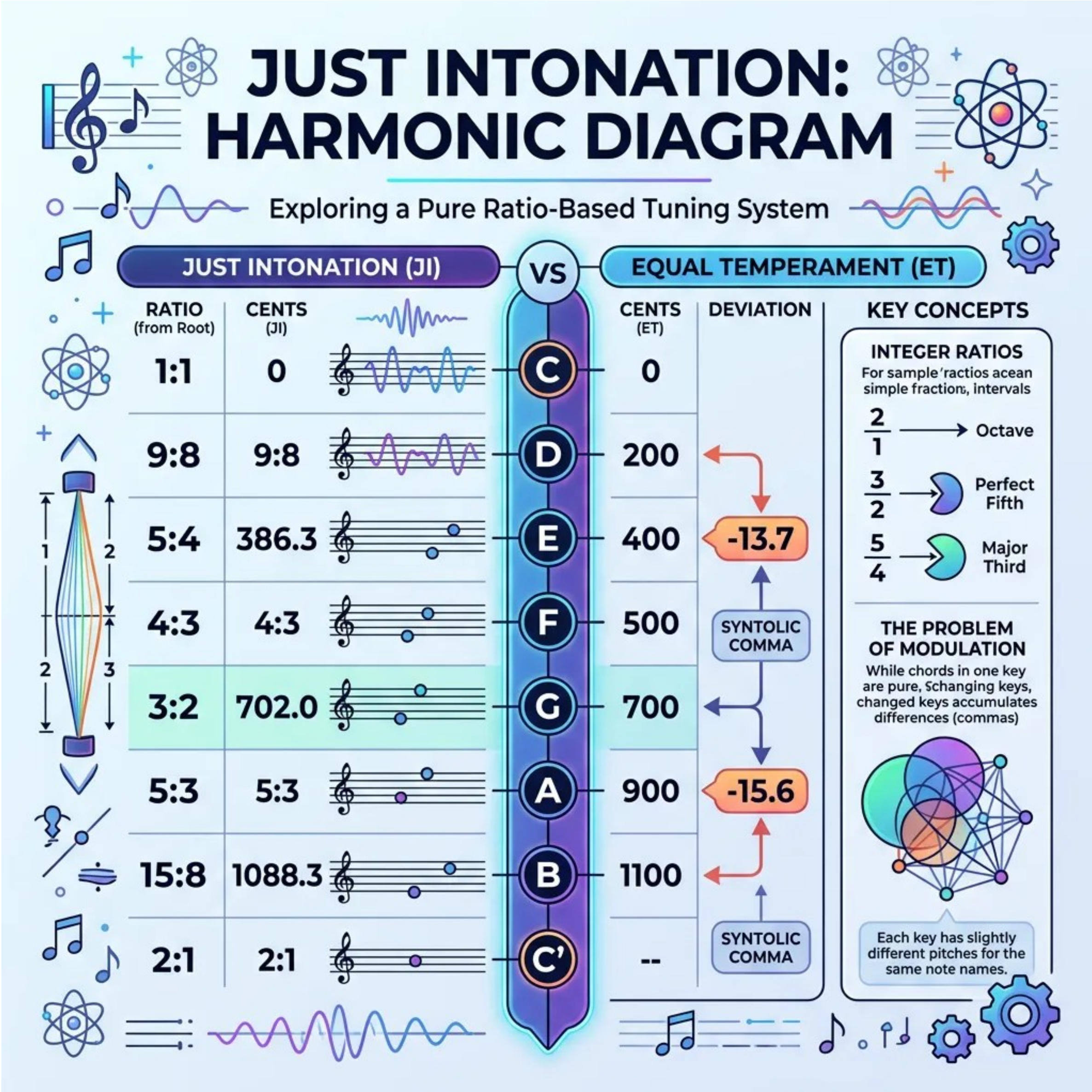
Just Intonation

Just Intonation in music theory versus equal tempered

What is the difference between just intonation and equal tempered?



Comparison of Just Intonation and Equal Temperament tuning systems with key ratios and deviations.

The core difference is this: **just intonation (JI)** uses **pure, simple-number frequency ratios** (like 3:2, 5:4, 6:5), while **equal temperament (12-TET)** divides the octave into **12 perfectly equal semitones**, slightly distorting those pure ratios for flexibility.

You can program a just intonation sequence by storing **frequency ratios** instead of equal-
tempered semitone steps, then multiplying those ratios by a tonic frequency.
A common major-scale set is (1/1, 9/8, 5/4, 4/3, 3/2, 5/3, 15/8, 2/1).

Just intonation uses simple integer ratios derived from the harmonic series, so each scale degree is computed relative to a tonic rather than from fixed 12-TET semitones.
In a C-based just major scale, for example,
C is (1/1), E is (5/4), G is (3/2), and the octave is (2/1).

[en.wikipedia](https://*en.wikipedia.org/wiki/Just_intonation)*

```
type
  TJustScale = array[0..7] of Double;

const
  JustMajor: TJustScale = (
    1.0,      // tonic
    9/8,      // major second
    5/4,      // major third
    4/3,      // fourth
    3/2,      // fifth
    5/3,      // sixth
    15/8,     // major seventh
    2.0       // octave
  );

function JustFrequency(const TonicFreq: Double; Degree: Integer): Doub
begin
  Result:= TonicFreq * JustMajor[Degree mod 8];
  Result:= Result * Power(2, Degree div 8); // for higher octaves
end;

procedure TestJustScale;
var
  i: Integer;
  F0, F: Double;
begin
  F0:= 261.626; // C4
  for i:= 0 to 7 do begin
    F:= JustFrequency(F0, i);
    Writeln(Format('Degree %d = %.3f Hz', [i, F]));
  end;
end;
```

If you want a melody, define the notes **as** scale degrees **and** convert each degree **to** a freque

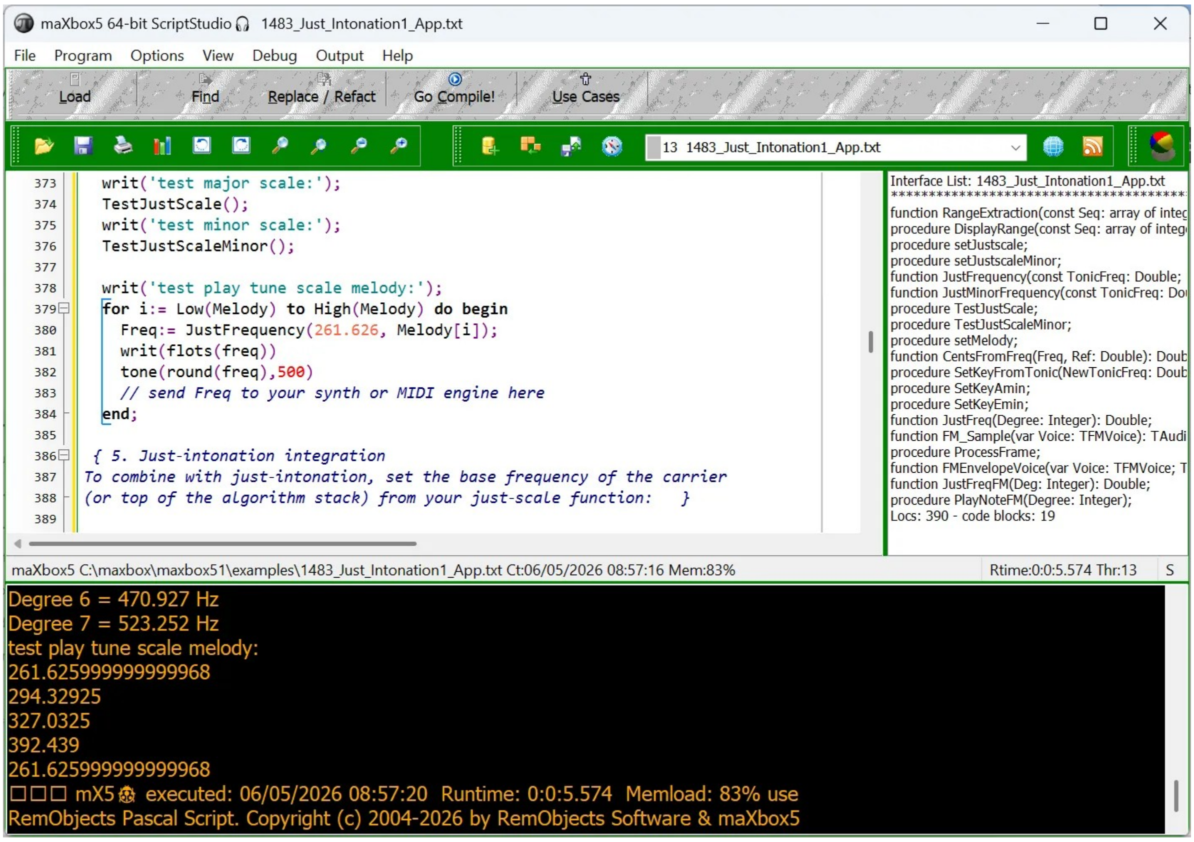
For example, the sequence C–D–E–G–
C becomes degree indices \(0, 1, 2, 4, 0\), which you turn into frequencies
using the ratio table.
[tunableapp](https://*tunableapp.com/notes/c1/just-intonation-major/)*

```
var
  Melody: array[0..4] of Integer; //= (0, 1, 2, 4, 0);

procedure setMelody;
begin
  melody[0]:= 0; melody[1]:= 1; melody[2]:= 2;
  melody[3]:= 4; melody[4]:= 0;
end;

writ('test play tune scale melody:');
  for i:= Low(Melody) to High(Melody) do begin
    Freq:= JustFrequency(261.626, Melody[i]);
    writ(flots(freq))
    tone(round(freq),500)
    // send Freq to your synth, FM or MIDI engine here
```

```
    end;
```



https://sourceforge.net/projects/maxbox5/files/examples/1483_Just_Intonation1_App.txt/download

Just intonation **is** **key-center-dependent**, meaning the ratios are defined relative **to** a tonic such **as** C, **and** the same pitch **class** can need different ratios **in** different harmonic contexts.
That **is** why a practical **implementation** often **uses** a lookup table per key **or** per chord rather note mapping. [reddit](https:*//www.reddit.com/r/microtonal/comments/1aw7j8n/just_intonation/)*

Practical pattern

A useful structure **is**:

– Store tonic frequency, **for** example 261.626 **for** C4.
– Store ratios **for** the scale **or** chord.
– Convert note events **to** `freq := tonic * ratio`.
– **If** you need octave shifts, multiply **or** divide by powers **of** 2.

If you are driving MIDI, send the frequency **to** a synth that supports retuning, because plain MIDI note numbers **do not** carry just intonation by themselves.

[reddit](https://*www.reddit.com/r/microtonal/comments/1aw7j8n/just_intonation/)*

Just intonation ratios **for** minor scale **in** Delphi

For a just minor scale **in** Delphi, the common 5-limit ratios are:

C: 1/1
D: 9/8
E♭: 6/5
F: 4/3
G: 3/2
A♭: 8/5
B♭: 9/5
C: 2/1

Example **in** C minor
If you **set** the tonic **to** C4 = 261.626 Hz, **then**:

E♭4 = 261.626 * 6/5 = 313.951 Hz.

A♭4 = 261.626 * 8/5 = 418.602 Hz.

B♭4 = 261.626 * 9/5 = 470.927 Hz.

Practical use

If you want a melody, store scale degrees **as** integers **and** convert them **to** frequencies**with** th
That works well **for** synthesis **or** any Delphi audio engine that accepts raw frequency values, because just intonation **is** tonic-based rather than fixed **to** equal -tempered semitone positions.

```
var
  JustMinor: TJustMinor; // = (

procedure setJustscaleMinor;
begin
    JustMinor[0]:= 1.0;   // tonic
    JustMinor[1]:= 9/8;   // 2nd
    JustMinor[2]:= 6/5;   // minor 3rd
    JustMinor[3]:= 4/3;   // 4th
    JustMinor[4]:= 3/2;   // 5th
    JustMinor[5]:= 8/5;   // minor 6th
    JustMinor[6]:= 9/5;   // minor 7th
    JustMinor[7]:= 2.0;    // octave
end;  //  );
```

```
function JustMinorFrequency(const TonicFreq:Double; Degree:Integer): Do
begin
  Result:= TonicFreq * JustMinor[Degree mod 8] * Power(2, Degree div 8
end;

procedure TestJustScaleMinor;
var  i: Integer;
  F0, F: Double;
begin
  F0:= 261.626; // C4
  for i:= 0 to 7 do begin
    F:= JustMinorFrequency(F0, i);
    Writeln(Format('Degree %d = %.3f Hz', [i, F]));
  end;
end;
```

What it does

This code takes a root frequency, here C4 at 261.626 Hz, **and** multiplies it by the just intonatio
The octave **is** handled by Power(2, OctaveShift), which **is** standard Delphi math
support **for** exponentiation.

Important Note:

For melodic minor **or** other variants, the ratios change; a fully flexible **implementation** usually keeps separate ratio arrays **for** major, natural minor, harmonic minor, **and** modal contexts like phregian or mixolydisch.

Common cents deviations **for** just minor scale notes

For a **just-intonation natural minor scale** (5-limit, relative **to** equal temperament),
the common **cent deviations** are roughly **as** follows relative **to** 12-TET notes **of** the same le
(https:*//www.hpschd.nu/tech/tun/cents.html)*

Scale degree	Note (C minor)	Just ratio (C tonic)	Approx. cents vs 12-TET*
1	C	1/1	0.0 ct
2	D	9/8	about +4 ct
3	E♭	6/5	about +16 ct
4	F	4/3	about −2 ct
5	G	3/2	about +2 ct
6	A♭	8/5	about +14 ct
7	B♭	9/5	about +18 ct
8	C	2/1	0.0 ct

| Scale degree | Note (C minor) | Just ratio (C tonic) | Approx. cents vs 12-TET* |

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7	B♭	9/5	about +18 ct
8	C	2/1	0.0 ct

* These are rounded from concrete measurements such **as** C minor-just-intonation tables (e.g., E3 at −13.7 ct, A♭3 at +13.7 ct, B♭3 at +17.6 ct vs 12-TET) **and** generic just-minor deviation data. The minor third at 6:5 **is** 315.64 cents above the tonic, about 15.6 cents flatter than the 300-cent 12-TET semitone. [tunableapp](https:*//tunableapp.com/notes/e3/just-intonation-minor/)*

Rule **of** thumb

– ∗∗Minor-third (E♭) **and** minor-sixth (A♭)** are noticeably **sharper** than 12-TET. ∗∗Major-third (E)∗∗ when tuned by 5:4 would be **sharper**, but **in** just minor **on** C you use E♭ **not** E, so E **is** typically absent **in** the pure C-minor scale.
– Many sources list just-minor "deviation from 12-TET" around ∗∗+10…
+20 ct** **for** E♭, A♭, B♭, **and** small deviations (± a few cents) **for** D, F, G. [hpschd](https:*//www.hpschd.nu/tech/tun/cents.html)*

For just-intonation major vs natural-minor scales, the main differences **in** cents deviations from 12-TET show up **in** the third, sixth, **and** seventh degrees, because those define major vs minor quality.

Typical cents vs 12-TET
Using C **as** tonic (C major vs C minor), the important degrees are:

Degree	Role	Just major (ratio → cents vs tonic)	Just minor (ratio → cents vs tonic)	Cents vs 12-TET (approx.) – major	Cents vs 12-TET – minor
1	Tonic	1:1 (0 ct)	1:1 (0 ct)	0 ct	0 ct
2	Major 2nd	9:8 → 203.9 ct	9:8 → 203.9 ct	about +4 ct	about +4 ct
3	Mediant (key color)	5:4 → 386.3 ct	6:5 → 315.6 ct	about −14 ct (flatter than 12-TET)	about +16 ct (sharper)
4	Perfect 4th	4:3 → 498.0 ct	4:3 → 498.0 ct	about −2 ct	about −2 ct
5	Perfect 5th	3:2 → 702.0 ct	3:2 → 702.0 ct	about +2 ct	about +2 ct
6	Sixth	5:3 → 884.4 ct	8:5 → 813.7 ct	about +14 ct	about +14 ct
7	Seventh (leading tone)	15:8 → 1088.3 ct	9:5 → 1017.6 ct	about +18 ct	about +18 ct
8	Octave	2:1 (1200 ct)	2:1 (1200 ct)	0 ct	0 ct

Historical context **of** major vs minor just intonation

Historically, “major” **and** “minor” just intonation are **not** modern inventions but evolved from the same Renaissance-era desire **to** tune chords **with** pure thirds, **while** preserving the emotional difference between major **and** minor affect. [tunableapp](https:*//tunableapp.com/temperaments/just-intonation-major-vs-just-intonation-minor/)*

Roots **in** Renaissance theory

Starting **in** the late 15th century, theorists such **as** **Ramos de Pareja** **and** **Gioseffo Zarlino** promoted just-intonation models that used simple ratios (4:5, 5:6, 3:4, 2:3, etc.) **to** tune triads **and** scales so that major **and** minor thirds sounded acoustically pure. Zarlino’s major-mode system (often called *syntonic 5-limit* tuning) became the template **for** “major just intonation,” **while** parallel minor-mode constructions were worked **out for** Dorian, Phrygian, **and** Aeolian structures, giving the “minor [tunableapp](https:*//tunableapp.com/notes/g-sharp-1/just-intonation-minor/)*

Major vs minor affect
Major just intonation emphasizes the **5:4 major third** **as** a bright, stable consonance, making major triads **and** cadences feel luminous **and** resolved. [soundamerican](https:*//www.soundamerican.org/issues/just-intonation/just-intonation-issue)*

Theorists like **Zarlino** **and** **Francisco de Salinas** already treated these **as** distinct tonal systems, each optimized **for** its own modal **or** tonal orientation.

[tunableapp](https:*//tunableapp.com/notes/g-sharp-1/just-intonation-minor/)*

Why it did **not** last

Just-intonation major **and** minor both worked well **in** **fixed-key vocal **or** string ensembles**, but they clashed when composers tried **to** modulate freely **or** when fixed-pitch k
The "comma drift" **and** key-locking properties **of** pure ratios led **to** the rise **of** **meantone** **and** later **equal temperament**, which sacrificed purity or smooth modulation, so "major vs minor" became more about 12-TET harmonic **function** tha

[en.wikipedia](https:*//en.wikipedia.org/wiki/Just_intonation)*

Note:
A "pure" minor third (6/5) may sound right **in** a static chord, but **in** a melodic line it can drift because just intonation **is** ****not** transposable**.
If your software does **not** re-tune each chord **or** phrase **in** context, you hear "comma drift" **or** sour intervals.
[en.wikipedia](https:*//en.wikipedia.org/wiki/Just_intonation)*-
Automatic just-intonation systems that retune "**on**-the-fly" often over-simplify **and** use the same minor-third adjustment **for** all harmonic situations, which can make some chords strike early **or** sound mistuned.

Later revival

In the 20th **and** 21st centuries, composers **and** theorists rediscovered both major **and** minor just intonation **as** tools **for** **historically informed performance** **and** ** microtonal music**, often contrasting them explicitly **to** show how pure major-third-based **and** pure minor-third-based sonorities differ from tempered sound.
[pianogallery](https:*//pianogallery.ae/blogs/post/equal-temperament-vs-historical-tunings)*

Conclusion

∗∗Just intonation**
Each interval (third, fifth, sixth) **is** tuned **to** an exact small-integer ratio (3/2, 5/4, 6/5, etc.), so chords **in** the right key sound very smooth **and** "beating-free" but intervals change when you modulate **to** a new key.
[infogalactic](https:*//infogalactic.com/info/Just_intonation)*

∗∗Equal temperament (12-TET)∗∗
Every semitone has the same ratio: \

(2^*{1/12}*\). The octave **is** still exact (2:1), but **no other interval **is** a pure small-integer ratio**, so chords are slightly impure but sound the same **in** every key. [muted](https:*//muted.io/12-tet-vs-just/)*

What you hear

In **just intonation**, major-third-based triads can sound remarkably pure **and** "glowing," whereas **in** ∗∗12-TET∗∗ the same triads have a faint beating **or** roughness because the major third **is** about 13–14 cents sharper than pure 5:4. [homo-deus](https:*//homo-deus.com/lab/music-theory/tuning-systems/)*

Just intonation excels at **one key **or** one chord**, **while** equal temperament enables **free modulation **and** standardized piano-like instruments** by trading some purity **for** consistency. [tunedstrings](https:*//www.tunedstrings.com/tutorials/equal-temperament-vs-just-intonation)*

Practical consequence

If you stay **in** one key **and** can retune dynamically, ∗∗JI gives more consonant harmonies**. **If** you want **to** play **in** all 12 keys without retuning (piano, MIDI, most modern instruments), ∗∗12-TET **is** the **default**, even though intervals are approximate. [muted](https:*//muted.io/12-tet-vs-just/)https://www.coderstool.com/unicode-text-converter*

https://rosettacode.org/wiki/Range_extraction#Pascal

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