

- https://wiki.ccarh.org/wiki/MIDI_file_parsing_homework
- <https://www.cs.cmu.edu/~music/cmsip/readings/davids-midi-spec.htm>
- <https://www.cs.cmu.edu/~music/cmsip/readings/Standard-MIDI-file-format-updated.pdf>

Terminology:

- **beat = quarter note**
- **MIDI Tick**
 - arbitrary time unit for the Midi file.
- MIDI Clock
- **pulses per quarter note (PPQN) / pulses per quarter (PPQ) / ticks per quarter note (TPQN)**
 - **MIDI default is 48 ticks per quarter note**
 - https://en.wikipedia.org/wiki/Pulses_per_quarter_note
 - https://majicdesigns.github.io/MD_MIDIFile/page_timing.html
- **Set Tempo (in microseconds per MIDI quarter-note) FF 51 03 tt tt tt**
 - **tt tt tt** = (us / beat)
 - **Default: 500,000 us / beat**
 - $\Rightarrow 0.5 \text{ s / beat}$
 - $\Rightarrow 120 \text{ BPM}$
 - **BPS** = $1,000,000 / (\text{tt tt tt})$
 - **BPM** = $60 * \text{beats / second} = 60,000,000 / (\text{tt tt tt})$
 - <http://midi.teragonaudio.com/tech/midifile/tempo.htm>
 - <http://midi.teragonaudio.com/tech/midifile/ppqn.htm>
- **Time Signature: FF 58 04 nn dd cc bb**
 - **nn** / (2^{dd}) = time signature
 - **cc** = (# of of MIDI clocks / metronome click)
 - **bb** = (# of notated 32nd-notes / MIDI quarter-note (24 MIDI clocks))
- **(MIDI ticks / second) = (MIDI ticks / beat) * (beats / second)**
 - **Default to $48 * (120/60) = 96$**
- **(us / MIDI tick) = $1,000,000 / (\text{MIDI ticks / second})$**
- **1 MIDI quarter note = 24 MIDI Clocks**
- 24ths of a microsecond per MIDI clock
- Time Signature
- delta time

Sample Twinkle Twinkle

4D 54 68 64 (MThd)

00 00 00 06

00 01 (format 1 = one or more simultaneous tracks)

00 03 (3 tracks)

01 80 (0x180 = 384 ticks/quarter note (TPQN))

4D 54 72 6B (MTrk)

00 00 01 D2 (Chunk length 0x01D2 = 466 bytes follow)

00

FF 58 04 04 02 18 08 (time signature)

00

FF 51 03 08 52 AE (tempo = 0x0852AE = 545,454 us/beat $\Rightarrow$ 2.1812 seconds / measure $\Leftrightarrow$ 110 BPM)

00

FF 03 15 45 6C 65 63 2E 20 50 69 61 6E 6F 20 28 43 6C 61 73 73 69 63 29 (Elec. Piano (Classic)) - sky blue

00

C0 00 (Program Change on ch 0)

00 (0 delta MIDI ticks)

90 3C 32 (0x90 = Note ON event, 0x3C = Note 60 (C4), 0x32 = 50 velocity)

81 40 ([Variable length encoding](#) 1|000|0001 0|100|0000 $\Rightarrow$ 000|0001|100|0000 = 192 ticks)

80 3C 00 (0x80 = Note OFF event, 0x3C = Note 60 (C4))

81 40

90 3C 32

81 40

80 3C 00

81 40

90 43 3

81 40

80 43 00

81 40

90 43 32

81 40

80 43 00

81 40

90 45 32

81 40

80 45 00

81 40

90 45 32

81 40

80 45 00

81 40
90 43 32
83 00 ([Variable length encoding](#) 1000|0011 0000|0000 ⇒ 00000110000000 = 384 ticks)
80 43 00
83 00
90 41 32
81 40
80 41 00
81 40
90 41 32
81 40
80 41 00
81 40
90 40 32
81 40
80 40 00
81 40
90 40 32
81 40
80 40 00
81 40
90 3E 32
81 40
80 3E 00
81 40
90 3E 32
81 40
80 3E 00
81 40
90 3C 32
83 00
80 3C 00
83 00
90 43 32
81 40
80 43 00
81 40
90 43 32
81 40
80 43 00
81 40
90 41 32
81 40
80 41 00

81 40
90 41 32
81 40
80 41 00
81 40
90 40 32
81 40
80 40 00
81 40
90 40 32
81 40
80 40 00
81 40
90 3E 32
83 00
80 3E 00
83 00
90 43 32
81 40
80 43 00
81 40
90 43 32
81 40
80 43 00
81 40
90 41 32
81 40
80 41 00
81 40
90 41 32
81 40
80 41 00
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90 40 32
81 40
80 40 00
81 40
90 40 32
81 40
80 40 00
81 40
90 3E 32
83 00
80 3E 00

83 00
90 3C 32
81 40
80 3C 00
81 40
90 3C 32
81 40
80 3C 00
81 40
90 43 32
81 40
80 43 00
81 40
90 43 32
81 40
80 43 00
81 40
90 45 32
81 40
80 45 00
81 40
90 45 32
81 40
80 45 00
81 40
90 43 32
83 00
80 43 00
83 00
90 41 32
81 40
80 41 00
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90 41 32
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80 41 00
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90 40 32
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80 40 00
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90 40 32
81 40
80 40 00

81 40

90 3E 32

81 40

80 3E 00

81 40

90 3E 32

81 40

80 3E 00

81 40

90 3C 32

83 00

80 3C 00

00

FF 2F 00 (End of Track)

4D 54 72 6B (MTrk)

00 00 00 ED

00

FF 03 0A 56 69 62 72 61 70 68 6F 6E 65 (Vibraphone) - very light blue

00

C1 0B (C1 = Program Change (C) on channel 1. Program 0xB = 11)

00

91 3C 32

86 00 ([Variable length encoding](#) 1000|0110 0000|0000 $\Rightarrow$ 00001100000000 = 768 ticks = 2 quarter notes)

81 3C 00

00

91 43 32

86 00

81 43 00

00

91 45 32

86 00

81 45 00

00

91 43 32

86 00

81 43 00

00

91 41 32

86 00

81 41 00

00

91 40 32

86 00
81 40 00
00
91 3E 32
86 00
81 3E 00
00
91 3C 32
86 00
81 3C 00
00
91 43 32
86 00
81 43 00
00
91 41 32
86 00
81 41 00
00
91 40 32
86 00
81 40 00
00
91 3E 32
86 00
81 3E 00
00
91 43 32
86 00
81 43 00
00
91 41 32
86 00
81 41 00
00
91 40 32
86 00
81 40 00
00
91 3E 32
86 00
81 3E 00
00
91 3C 32

86 00
81 3C 00
00

91 43 32
86 00
81 43 00
00

91 45 32
86 00
81 45 00
00

91 43 32
86 00
81 43 00
00

91 41 32
86 00
81 41 00
00

91 40 32
86 00
81 40 00
00

91 3E 32
86 00
81 3E 00
00

91 3C 32
86 00
81 3C 00
00

FF 2F 00 (End of Track)

4D 54 72 6B (MTrk)

00 00 01 88
00

FF 03 09 4D 75 73 69 63 20 42 6F 78 (Music Box) - Teal
00

C2 0A
00

92 48 32
83 00
82 48 00
00

	92 48 32
83 00	
	82 48 00
00	
	92 4F 32
83 00	
	82 4F 00
00	
	92 4F 32
83 00	
	82 4F 00
00	
	92 51 32
60	
	82 51 00
60	
	92 53 32
60	
	82 53 00
60	
	92 54 32
60	
	82 54 00
60	
	92 51 32
60	
	82 51 00
60	
	92 4F 32
86 00	
	82 4F 00
00	
	92 4D 32
86 00	
	82 4D 00
00	
	92 4C 32
86 00	
	82 4C 00
00	
	92 4A 32
60	
	82 4A 00
60	

92 4C 32
60
82 4C 00
60
92 4D 32
60
82 4D 00
60
92 4A 32
60
82 4A 00
60
92 48 32
86 00
82 48 00
00
92 4F 32
86 00
82 4F 00
00
92 4D 32
86 00
82 4D 00
00
92 4C 32
60
82 4C 00
60
92 4D 32
60
82 4D 00
60
92 4F 32
60
82 4F 00
60
92 4C 32
60
82 4C 00
60
92 4A 32
86 00
82 4A 00
00

92 4F 32
86 00
82 4F 00
00
92 4D 32
86 00
82 4D 00
00
92 4C 32
60
82 4C 00
60
92 4D 32
60
82 4D 00
60
92 4F 32
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82 4F 00
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92 4C 32
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82 4C 00
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92 4A 32
86 00
82 4A 00
00
92 48 32
86 00
82 48 00
00
92 4F 32
86 00
82 4F 00
00
92 51 32
60
82 51 00
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92 53 32
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82 53 00
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92 54 32
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82 54 00
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92 51 32
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82 51 00
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92 4F 32
86 00
82 4F 00
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92 4D 32
86 00
82 4D 00
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92 4C 32
86 00
82 4C 00
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92 4A 32
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82 4A 00
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92 4C 32
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82 4C 00
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92 4D 32
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82 4D 00
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92 4A 32
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82 4A 00
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92 48 32
86 00
82 48 00
00
FF 2F 00