CS 1124 Media Computation

7.2 Sound(2)
October 8, 2008
Steve Harrison

TODAY

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5

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Sounds as arrays

- Samples are just stored one right after the other in the computer's memory
- That's called an *array*

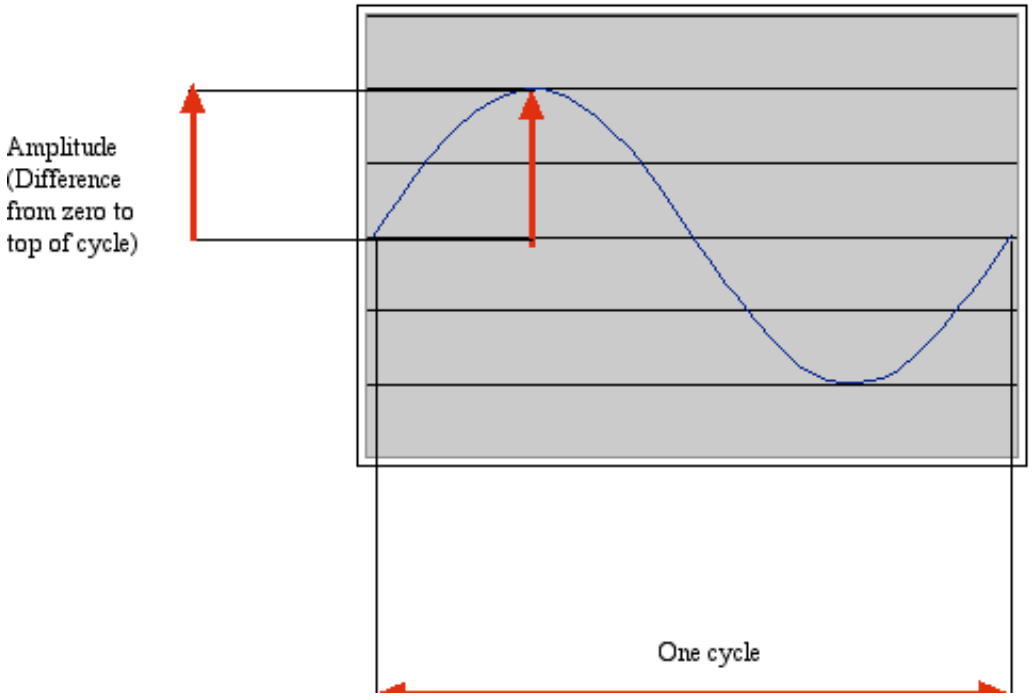
(Like pixels in a picture)

  - **It's an especially efficient (quickly accessed) memory structure**
  - **each sample is two bytes (or ONE WORD)**

byte #	1	2	3	4	5	6	7
byte contents	0	56	1	223	256	2	...
word contents	56		478		-32766		

How sound works: Acoustics, the physics of sound

- Sounds are waves of air pressure
  - **Sound comes in cycles**
  - **The frequency of a wave is the number of cycles per second (cps), or Hertz**
    - (Complex sounds have more than one frequency in them.)
  - **The amplitude is the maximum height of the wave**



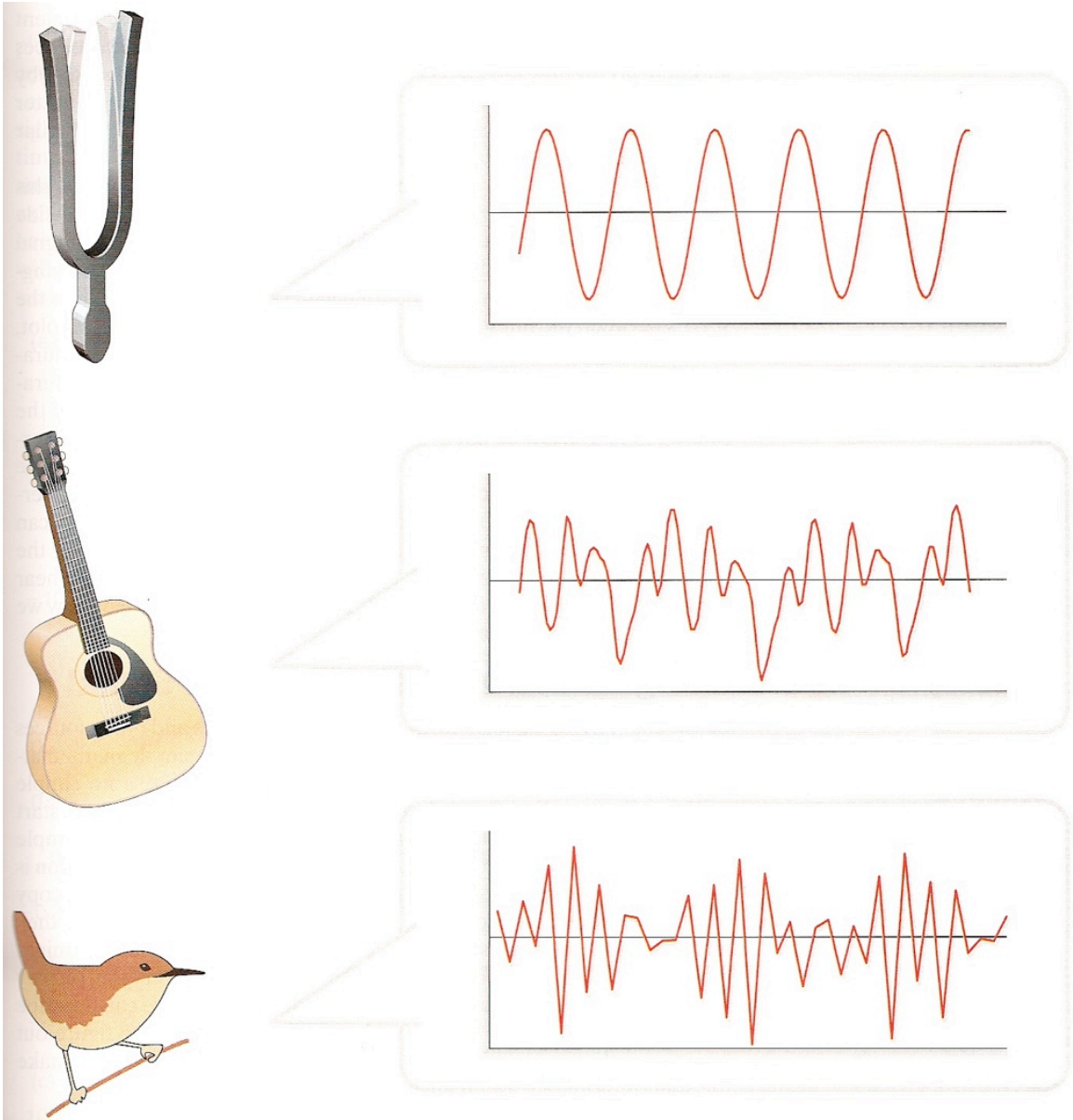


Figure 2.11 Three sound sources—a tuning fork, a guitar, and a bird—and the sound signals they create.

the sounds more rich and realistic.

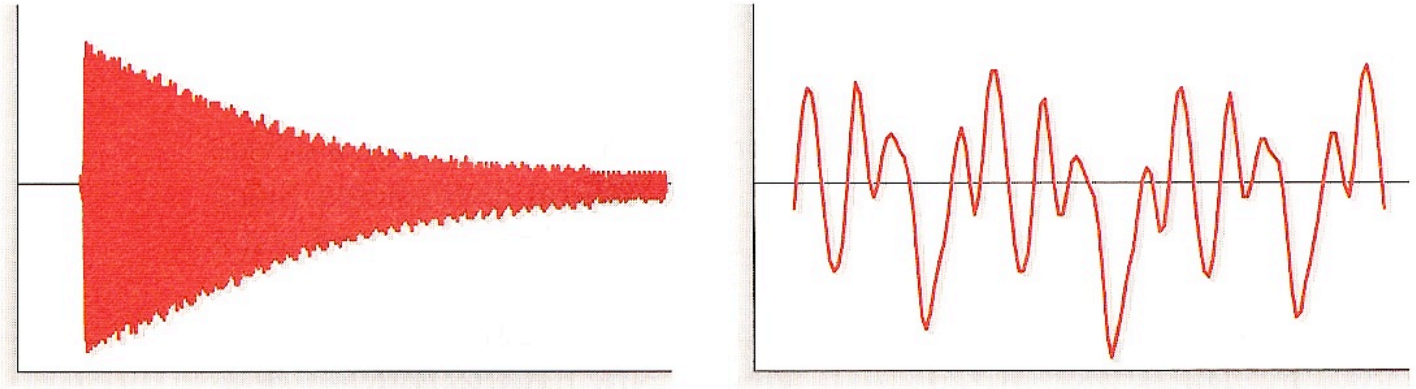


Figure 2.12 The guitar signal in Figure 2.11 shown over two different time scales. The plot on the left shows several seconds of the signal, while the plot on the right shows several milliseconds of the signal.

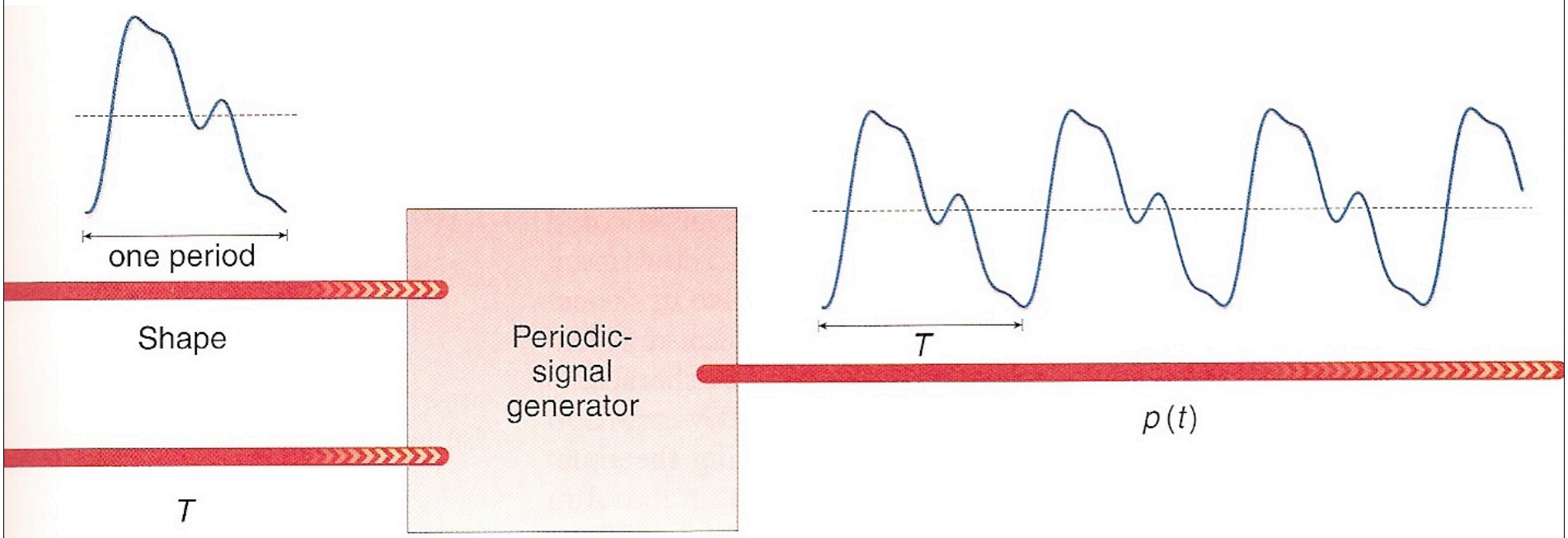


Figure 2.16 Block diagram of the periodic-signal generator.

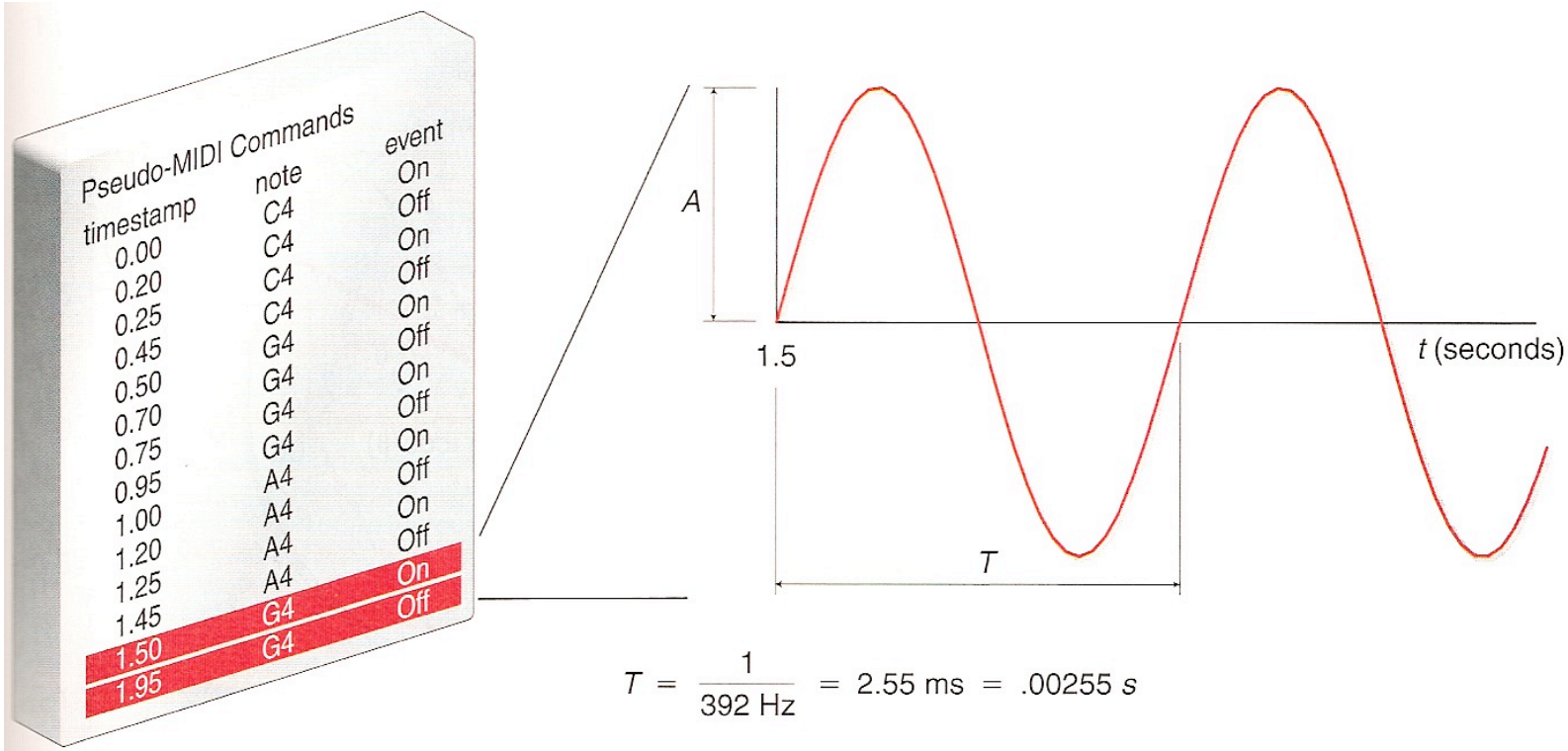


Figure 2.22 MIDI file producing a sinusoidal signal for the note G4 with a frequency of 392 Hz. The amplitude A and period T of the signal are shown.

Representations of Sound and Images

- Kind of the same idea:
  - **number represents the colors at each pixel**
  - **number represents the fragment of sound wave at very tiny moment in time**
- But different, too:
  - **blow up a pixel -> looks like a fragment of picture**
  - **blow up a sample, doesn't sound like much -- WHY?**
    - sound is made by changes in value

```
def changeSampleAt( sound, location) :
  sampleLength = getLength( sound)
  setTo = getSampleValueAt( sound, location )
  for num in range( 1, sampleLength ):
    setSampleValueAt(sample, num, setTo )
  return sound
```

But isn't light made of waves, too?

- Yes, but we don't represent the parts of a light wave.
  - **the color the number makes on the computer screen generates the waves we see**

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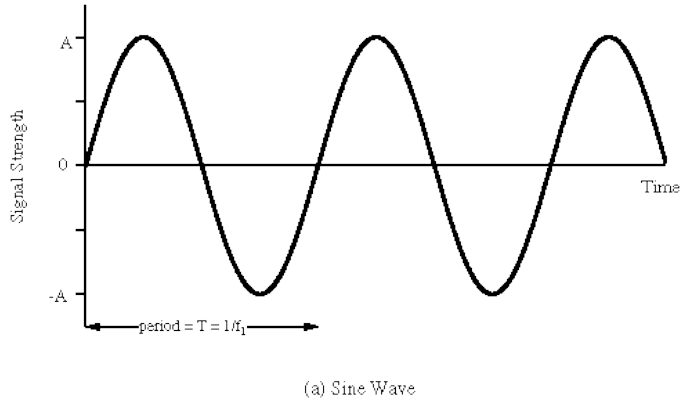
Sine wave



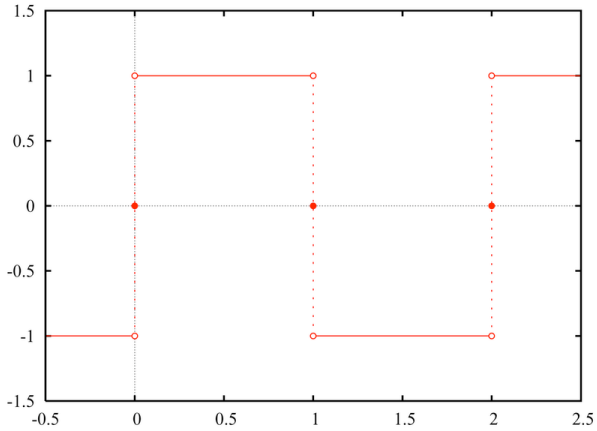
(a) Sine Wave

- recipe 70

```
def sineWave( freq, amplitude ) :
  mySound = getMediaPath("sec1silence.wav")
  buildSin = makeSound(mySound)
  sr = getSamplingRate(buildSin)  # sampling rate
  interval = 1.0 / freq                  # interval of sample
  samplesPerCycle = interval * sr    # samples / cycle
  maxCycle = 2 * pi
  for pos in range( 1, getLength( buildSin ) + 1 ) :
    rawSample = sin(( pos / samplesPerCycle) * maxCycle)
    sampleVal = int( amplitude * rawSample )
    setSampleValueAt( buildSin, pos, sampleVal )
  return buildSin
```

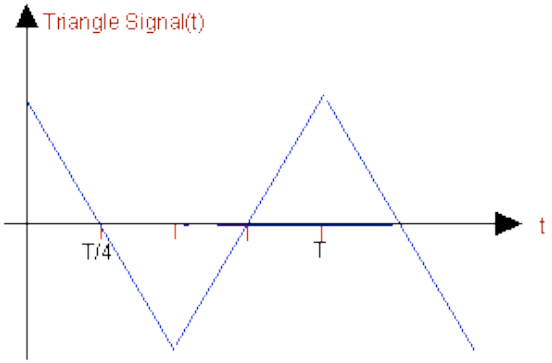
Square wave

- recipe 72




```
def squareWave( freq, amplitude ) :
  mySound = getMediaPath("sec1silence.wav")
  square = makeSound(mySound)
  samplingRate = getSamplingRate(square)   # sampling rate
  seconds = 1
  interval = 1.0 * seconds / freq                    # interval of sample
  samplesPerCycle = interval * samplingRate # samples / cycle
  samplesPerHalfCycle = int(samplesPerCycle / 2)
  sampleVal = amplitude
  i = 1
  for s in range( 1, getLength( square ) + 1 ) :
    if (i > samplesPerHalfCycle):
      sampleVal = sampleVal * -1
      i = 0
    setSampleValueAt( square,s, sampleVal )
    i = i + 1
  return square
```

Triangluar wave



- recipe 73, modified

```
def triangleWave( freq ) :
  amplitude = 6000
  samplingRate = 22050                          # sampling rate
  seconds = 1
  triangle = makeEmptySound( seconds  )     # create a sound object (the book uses “sec1silence.wav”)
  interval = 1.0 * seconds / freq               # interval of sample
  samplesPerCycle = interval * samplingRate # samples / cycle
  samplesPerHalfCycle = int(samplesPerCycle / 2)
  increment = int( amplitude / samplesPerHalfCycle )
  sampleVal = -amplitude
  i = 1
  for s in range( 1, samplingRate + 1 ) :
    if (i > samplesPerHalfCycle):
      increment = increment * -1
      i = 0
    sampleVal = sampleVal + increment
    setSampleValueAt( triangle, s, sampleVal )
    i = i + 1
  return triangle                               # return the sound (the book says play)
```

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Shifting the frequency

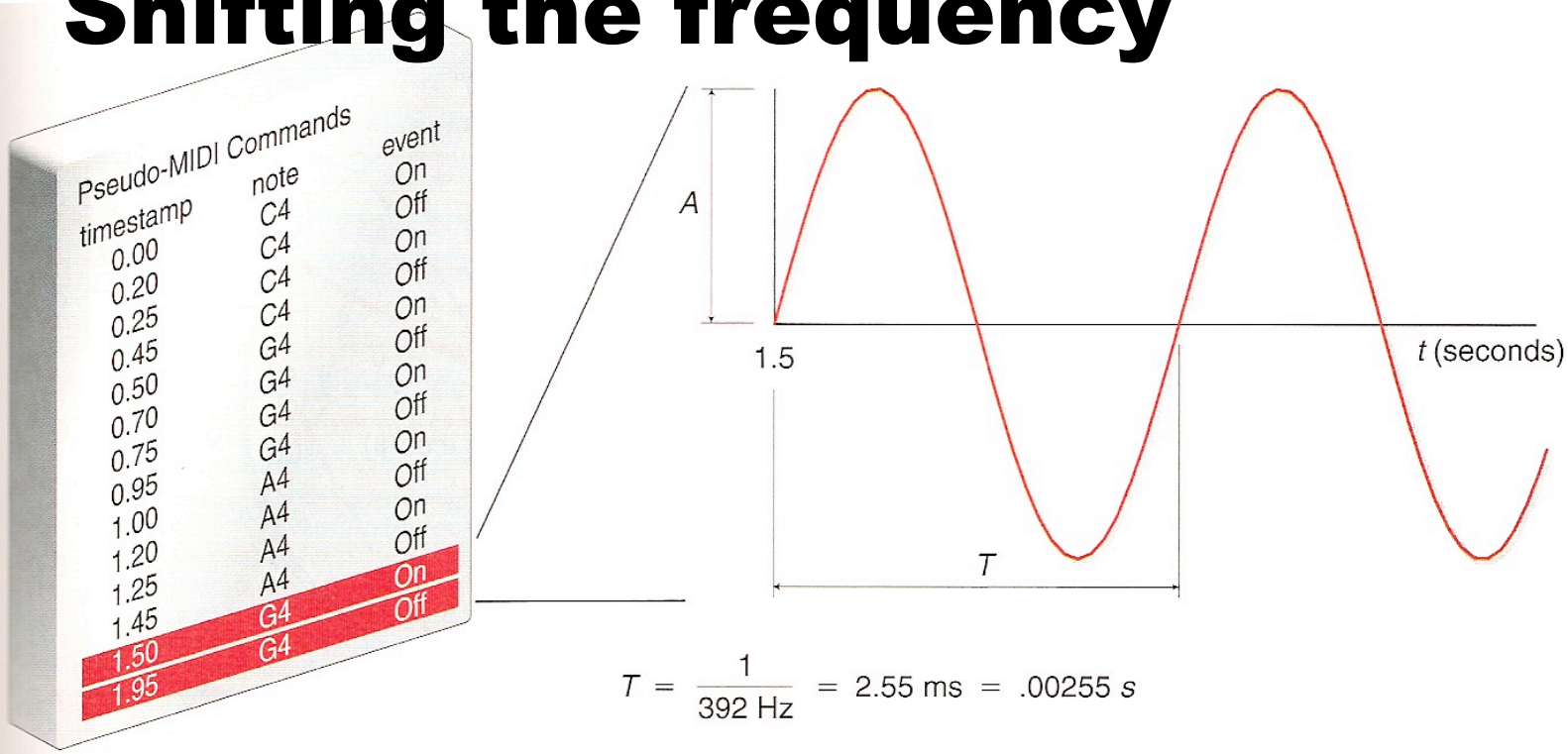

Figure 2.22 MIDI file producing a sinusoidal signal for the note G4 with a frequency of 392 Hz. The amplitude A and period T of the signal are shown.

Notice that higher frequencies take less time and lower frequencies take more time. Changing the frequency of a sound changes its duration and vice-versa.

Shifting the frequency

- recipe 68, modified
- how sampling keyboards work....
- A lot like scaling pictures, isn't it?

```
def shift( soundFile, factor ) :
  source = makeSound( soundFile )
  target = makeSound( soundFile )
  sourceIndex = 1
  sourceLength = getLength( source )
  for targetIndex in range( 1, sourceLength + 1 ) :
    setSampleValueAt( target, targetIndex, getSampleValueAt( source, int( sourceIndex ))))
    sourceIndex = sourceIndex + factor
    if sourceIndex > sourceLength :
      sourceIndex = 1
  return target
```

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Adding sounds - like combining pictures!

- recipe 71 (part 2)

```
def addSounds( sound1, sound2) :
  for index in range( 1, getLength(sound1) + 1 ) :
    s1Sample = getSampleValueAt( sound1, index )
    s2Sample = getSampleValueAt( sound2, index )
    setSampleValueAt( sound2, index, s1Sample + s2Sample )
  return sound2
```

What would happen if we added two normalized sounds?

How would you change this to add different length sounds?

Echo, echo, echo, echo

- recipe 64

```
def echoes( soundFile, delay, num ) :
  s1 = makeSound( soundFile )
  ends1 = getLength( s1 )
  ends2 = ends1 + (delay - num)
  s2 = makeEmptySound(1 + int( ends2 / getSamplingRate(s1)  )  )
  echoAmplitude = 1.0
  for echoCount in range( 1, num + 1 ) :
    echoAmplitude = echoAmplitude * 0.6        # each echo is 60% of previous
    for posn1 in range( 1, ends1 ) :
      posn2 = posn1 + (delay* echoCount )
      values1 = getSampleValueAt( s1, posn1) * echoAmplitude
      values2 = getSampleValueAt( s2, posn2)
      setSampleValueAt( s2, posn2, values1 + values2 )
  return s2
```

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Group Project 2: sound abstractions

- What should you do?
- Need to have everyone contribute a sound
- What rules should we create?
- Consider our experience with the visual abstractions.
- We'll decide next week.
- Only difference is that Friday (10/17) lab is to write specification & start writing code
- DUE Friday (10/24) 2:00 PM

Group Project 2: sound abstractions - EXTRA CREDIT

- Maybe we should have some ideas about abstract sound
- Extra credit Wednesday (10/15)
  - **Short report on abstract sound (5 minute max including demo)**
  - **presentation to class**
  - **Electronic music? Contemporary music? Sound artists?**
  - **worth same as EC for visual abstraction - one question on Final**

Group Project 2: sound abstractions - NEW GROUPS

1	2	3	4	5	6	7
Currin	Burke	Bowers	Davies	Ho	Dahyia	Burton
Demase	D'Augustine	Duffy	Heitzer	Howell	Ha	Highman
Malhotra	Maier	Hughes	Taylor	Merrow	Nassery	Rhyner
Regione	Talley	Knowles	Walsh	Slack	Pham	Thayer
Zhang	Tran	Messick			Roithmayr	

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Assignment 5

- Faster and Faster (or Higher and Higher)
- For a sound:
  - **increasingly compress the sound:**
    - 0% - 25% 1:1 (no compression)
    - 25%-50% 1:1.25
    - 50% - 75% 1:1.5
    - 75% -100% 1:2 (twice as fast)
  - **print out how much shorter in seconds the compressed sound is**
  - **save the sound to a file**

Assignment 5

- For extra credit on Final Exam
- For a sound:
  - **#comment that you are doing the challenge**
  - **increasingly compress the sound:**
    - 0% - 25% 1:1 (no compression)
    - 25% -100% smoothly change from 1:1 to 1:2 (twice as fast) instead of in steps
  - **print out how much shorter in seconds the compressed sound is**
    - this method should produce different results from basic
  - **save the sound to a file**

Questions?

- So what have we looked at today that could help with this HW?
- How?

COMING ATTARACTIONS

- Monday:
  - read chapters 7 & 8
  - quiz (on Chapter 8, only) due at 10:00 AM
- Next Wednesday
  - HW Project 5 due 10:00 am
- Next Friday:
  - come to class with Group Project 2 ideas