Teresa Van
10149274
CPSC 501 Assignment #4

Assignment #4: Profiler Reports

1. Profiler result before any changes:

```
   3947233 function calls (3947227 primitive calls) in 809.819 seconds

   Ordered by: standard name

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    0.016    0.016  809.819  809.819 <string>:1(<module>)
        2    0.000    0.000    0.000    0.000 <string>:12(__new__)
        1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
        2    0.000    0.000    0.001    0.001 _methods.py:28(_amin)
        4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
    22/16    0.000    0.000    0.001    0.000 chunk.py:122(read)
        2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
        6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
        6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
        2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
        2    0.000    0.000    0.031    0.016 convolve.py:18(LoadWaveFile)
        1    0.758    0.758    1.129    1.129 convolve.py:38(SaveWaveFile)
        1  680.948  680.948  680.948  680.948 convolve.py:49(Convolve)
        1  127.599  127.599  127.601  127.601 convolve.py:59(Normalize)
        1    0.000    0.000  809.803  809.803 convolve.py:75(Main)
        1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
        2    0.000    0.000    0.001    0.001 fromnumeric.py:2275(amin)
        2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
        2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
        2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
        4    0.000    0.000    0.000    0.000 wave.py:188(close)
        4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
        4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
        4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
        2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
        2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
        2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
        2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
        2    0.000    0.000    0.001    0.000 wave.py:233(readframes)
        2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
        1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
        1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
        1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
        1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
        1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.003    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7f03afbd49a0}
  1973510    0.233    0.000    0.233    0.000 {built-in method _struct.pack}
       12    0.030    0.003    0.030    0.003 {built-in method _struct.unpack_from}
        3    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000  809.819  809.819 {built-in method builtins.exec}
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
       33    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
        2    0.093    0.046    0.093    0.046 {built-in method numpy.core.multiarray.array}
        1    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.003    0.003    0.003    0.003 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973506    0.132    0.000    0.132    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
       20    0.001    0.000    0.001    0.000 {method 'read' of '_io.BufferedReader'
objects}
        3    0.002    0.001    0.002    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

2. Profiler result after algorithm-based optimization with FFT:

```
3947385 function calls (3947379 primitive calls) in 146.271 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1    0.014    0.014  146.271  146.271 <string>:1(<module>)
     2    0.000    0.000    0.000    0.000 <string>:12(__new__)
     1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
     2    0.000    0.000    0.002    0.001 _methods.py:28(_amin)
     4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
 22/16    0.000    0.000    0.001    0.000 chunk.py:122(read)
     2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
     6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
     6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
     2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
     2    0.000    0.000    0.133    0.066 fftpack.py:1013(rfftn)
     1    0.000    0.000    0.073    0.073 fftpack.py:1142(irfftn)
     2    0.000    0.000    0.129    0.065 fftpack.py:291(rfft)
     1    0.004    0.004    0.070    0.070 fftpack.py:380(irfft)
     3    0.007    0.002    0.188    0.063 fftpack.py:47(_raw_fft)
     3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
     3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
     2    0.000    0.000    0.002    0.001 fromnumeric.py:2275(amin)
     3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
     1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
     3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
     1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
     1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
     2    0.000    0.000    0.034    0.017 version1.py:20(LoadWaveFile)
     1    0.733    0.733    1.112    1.112 version1.py:40(SaveWaveFile)
     1    0.004    0.004    0.215    0.215 version1.py:50(FFTConvolve)
     1    0.000    0.000    0.000    0.000 version1.py:63(<listcomp>)
     2    0.000    0.000    0.000    0.000 version1.py:64(<genexpr>)
     1  144.792  144.792  144.795  144.795 version1.py:75(Normalize)
     1    0.000    0.000  146.257  146.257 version1.py:91(Main)
     2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
     2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
     2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
     4    0.000    0.000    0.000    0.000 wave.py:188(close)
     4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
     4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
     4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
     2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
     2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
     2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
     2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
     2    0.000    0.000    0.001    0.001 wave.py:233(readframes)
     2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
     1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
     1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
     1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
     1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
     1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
     1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.003    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7f11d83f99a0}
  1973509    0.239    0.000    0.239    0.000 {built-in method _struct.pack}
       12    0.033    0.003    0.033    0.003 {built-in method _struct.unpack_from}
        3    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000  146.271  146.271 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.118    0.008    0.118    0.008 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.059    0.059    0.059    0.059 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.095    0.047    0.095    0.047 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.027    0.027    0.027    0.027 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.003    0.003    0.003    0.003 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.134    0.000    0.134    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.001    0.000    0.001    0.000 {method 'read' of '_io.BufferedReader'
objects}
        3    0.003    0.001    0.003    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

3. Profiler result after “minimizing work inside loops”:

```
3947385 function calls (3947379 primitive calls) in 79.145 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1    0.014    0.014   79.145   79.145 <string>:1(<module>)
     2    0.000    0.000    0.000    0.000 <string>:12(__new__)
     1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
     2    0.000    0.000    0.002    0.001 _methods.py:28(_amin)
     4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
 22/16    0.000    0.000    0.001    0.000 chunk.py:122(read)
     2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
     6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
     6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
     2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
     2    0.000    0.000    0.132    0.066 fftpack.py:1013(rfftn)
     1    0.000    0.000    0.073    0.073 fftpack.py:1142(irfftn)
     2    0.000    0.000    0.129    0.064 fftpack.py:291(rfft)
     1    0.004    0.004    0.070    0.070 fftpack.py:380(irfft)
     3    0.006    0.002    0.188    0.063 fftpack.py:47(_raw_fft)
     3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
     3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
     2    0.000    0.000    0.002    0.001 fromnumeric.py:2275(amin)
     3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
     1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
     3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
     1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
     1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
     2    0.000    0.000    0.035    0.017 version2.py:20(LoadWaveFile)
     1    0.737    0.737    1.121    1.121 version2.py:40(SaveWaveFile)
     1    0.004    0.004    0.214    0.214 version2.py:50(FFTConvolve)
     1    0.000    0.000    0.000    0.000 version2.py:63(<listcomp>)
     2    0.000    0.000    0.000    0.000 version2.py:64(<genexpr>)
     1   77.662   77.662   77.665   77.665 version2.py:75(Normalize)
     1    0.000    0.000   79.131   79.131 version2.py:91(Main)
     2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
     2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
     2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
     4    0.000    0.000    0.000    0.000 wave.py:188(close)
     4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
     4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
     4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
     2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
     2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
     2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
     2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
     2    0.000    0.000    0.001    0.001 wave.py:233(readframes)
     2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
     1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
     1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
     1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
     1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
     1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.003    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7fa0d3ff59a0}
  1973509    0.244    0.000    0.244    0.000 {built-in method _struct.pack}
       12    0.033    0.003    0.033    0.003 {built-in method _struct.unpack_from}
        3    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000   79.145   79.145 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.111    0.007    0.111    0.007 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.059    0.059    0.059    0.059 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.095    0.047    0.095    0.047 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.027    0.027    0.027    0.027 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.003    0.003    0.003    0.003 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.134    0.000    0.134    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.001    0.000    0.001    0.000 {method 'read' of '_io.BufferedReader'
objects}
        3    0.003    0.001    0.003    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

4. Profiler result after “unrolling”:

```
3947385 function calls (3947379 primitive calls) in 1.461 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1    0.014    0.014    1.461    1.461 <string>:1(<module>)
     2    0.000    0.000    0.000    0.000 <string>:12(__new__)
     1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
     2    0.000    0.000    0.002    0.001 _methods.py:28(_amin)
     4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
 22/16    0.000    0.000    0.001    0.000 chunk.py:122(read)
     2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
     6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
     6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
     2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
     2    0.000    0.000    0.130    0.065 fftpack.py:1013(rfftn)
     1    0.000    0.000    0.071    0.071 fftpack.py:1142(irfftn)
     2    0.000    0.000    0.127    0.063 fftpack.py:291(rfft)
     1    0.003    0.003    0.068    0.068 fftpack.py:380(irfft)
     3    0.006    0.002    0.185    0.062 fftpack.py:47(_raw_fft)
     3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
     3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
     2    0.000    0.000    0.002    0.001 fromnumeric.py:2275(amin)
     3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
     1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
     3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
     1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
     1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
     2    0.000    0.000    0.035    0.018 version3.py:20(LoadWaveFile)
     1    0.720    0.720    1.100    1.100 version3.py:40(SaveWaveFile)
     1    0.004    0.004    0.211    0.211 version3.py:50(FFTConvolve)
     1    0.000    0.000    0.000    0.000 version3.py:63(<listcomp>)
     2    0.000    0.000    0.000    0.000 version3.py:64(<genexpr>)
     1    0.004    0.004    0.007    0.007 version3.py:75(Normalize)
     1    0.000    0.000    1.447    1.447 version3.py:86(Main)
     2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
     2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
     2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
     4    0.000    0.000    0.000    0.000 wave.py:188(close)
     4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
     4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
     4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
     2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
     2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
     2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
     2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
     2    0.000    0.000    0.001    0.001 wave.py:233(readframes)
     2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
     1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
     1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
     1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
        1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.003    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7efc762759a0}
  1973509    0.241    0.000    0.241    0.000 {built-in method _struct.pack}
       12    0.034    0.003    0.034    0.003 {built-in method _struct.unpack_from}
        3    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000    1.461    1.461 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.110    0.007    0.110    0.007 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.058    0.058    0.058    0.058 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.093    0.047    0.093    0.047 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.027    0.027    0.027    0.027 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.003    0.003    0.003    0.003 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.132    0.000    0.132    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.001    0.000    0.001    0.000 {method 'read' of '_io.BufferedReader'
objects}
        3    0.003    0.001    0.003    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

5. Profiler result after “strength reduction”:

```
   3947385 function calls (3947379 primitive calls) in 1.540 seconds

   Ordered by: standard name

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    0.022    0.022    1.540    1.540 <string>:1(<module>)
        2    0.000    0.000    0.000    0.000 <string>:12(__new__)
        1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
        2    0.000    0.000    0.002    0.001 _methods.py:28(_amin)
        4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
    22/16    0.000    0.000    0.001    0.000 chunk.py:122(read)
        2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
        6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
        6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
        2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
        2    0.000    0.000    0.145    0.073 fftpack.py:1013(rfftn)
        1    0.000    0.000    0.074    0.074 fftpack.py:1142(irfftn)
        2    0.000    0.000    0.142    0.071 fftpack.py:291(rfft)
        1    0.004    0.004    0.071    0.071 fftpack.py:380(irfft)
        3    0.007    0.002    0.202    0.067 fftpack.py:47(_raw_fft)
        3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
        3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
        1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
        2    0.000    0.000    0.002    0.001 fromnumeric.py:2275(amin)
        3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
        3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
        3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
        1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
        3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
        1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
        1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
        2    0.000    0.000    0.035    0.017 version4.py:20(LoadWaveFile)
        1    0.742    0.742    1.133    1.133 version4.py:40(SaveWaveFile)
        1    0.005    0.005    0.229    0.229 version4.py:50(FFTConvolve)
        1    0.000    0.000    0.000    0.000 version4.py:63(<listcomp>)
        2    0.000    0.000    0.000    0.000 version4.py:64(<genexpr>)
        1    0.020    0.020    0.023    0.023 version4.py:75(Normalize)
        1    0.001    0.001    1.518    1.518 version4.py:86(Main)
        2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
        2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
        2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
        4    0.000    0.000    0.000    0.000 wave.py:188(close)
        4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
        4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
        4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
        2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
        2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
        2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
        2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
        2    0.000    0.000    0.001    0.001 wave.py:233(readframes)
        2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
        1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
        1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
        1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
        1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.004    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7fd01492e9a0}
  1973509    0.247    0.000    0.247    0.000 {built-in method _struct.pack}
       12    0.033    0.003    0.033    0.003 {built-in method _struct.unpack_from}
        3    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000    1.540    1.540 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.114    0.008    0.114    0.008 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.061    0.061    0.061    0.061 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.105    0.052    0.105    0.052 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.030    0.030    0.030    0.030 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.004    0.004    0.004    0.004 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.137    0.000    0.137    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.001    0.000    0.001    0.000 {method 'read' of '_io.BufferedReader'
objects}
        3    0.003    0.001    0.003    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

6. Profiler result after “initialize at compile time”:

```
3947385 function calls (3947379 primitive calls) in 1.538 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1    0.022    0.022    1.538    1.538 <string>:1(<module>)
     2    0.000    0.000    0.000    0.000 <string>:12(__new__)
     1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
     2    0.000    0.000    0.002    0.001 _methods.py:28(_amin)
     4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
 22/16    0.000    0.000    0.002    0.000 chunk.py:122(read)
     2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
     6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
     6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
     2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
     2    0.000    0.000    0.131    0.066 fftpack.py:1013(rfftn)
     1    0.000    0.000    0.074    0.074 fftpack.py:1142(irfftn)
     2    0.000    0.000    0.128    0.064 fftpack.py:291(rfft)
     1    0.004    0.004    0.071    0.071 fftpack.py:380(irfft)
     3    0.006    0.002    0.188    0.063 fftpack.py:47(_raw_fft)
     3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
     3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
     2    0.000    0.000    0.002    0.001 fromnumeric.py:2275(amin)
     3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
     1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
     3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
     1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
     1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
     2    0.000    0.000    0.035    0.017 version5.py:21(LoadWaveFile)
     1    0.745    0.745    1.141    1.141 version5.py:41(SaveWaveFile)
     1    0.005    0.005    0.215    0.215 version5.py:51(FFTConvolve)
     1    0.000    0.000    0.000    0.000 version5.py:64(<listcomp>)
     2    0.000    0.000    0.000    0.000 version5.py:65(<genexpr>)
     1    0.024    0.024    0.027    0.027 version5.py:76(Normalize)
     1    0.001    0.001    1.515    1.515 version5.py:87(Main)
     2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
     2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
     2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
     4    0.000    0.000    0.000    0.000 wave.py:188(close)
     4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
     4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
     4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
     2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
     2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
     2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
     2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
     2    0.000    0.000    0.002    0.001 wave.py:233(readframes)
     2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
     1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
        1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
        1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
        1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.003    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7f86656f19a0}
  1973509    0.251    0.000    0.251    0.000 {built-in method _struct.pack}
       12    0.033    0.003    0.033    0.003 {built-in method _struct.unpack_from}
        3    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000    1.538    1.538 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.113    0.008    0.113    0.008 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.061    0.061    0.061    0.061 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.094    0.047    0.094    0.047 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.027    0.027    0.027    0.027 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.003    0.003    0.003    0.003 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.138    0.000    0.138    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.002    0.000    0.002    0.000 {method 'read' of '_io.BufferedReader'
objects}
        3    0.004    0.001    0.004    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

7. Profiler result after “exploit algebraic identities”:

```
3947382 function calls (3947376 primitive calls) in 1.564 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1    0.015    0.015    1.564    1.564 <string>:1(<module>)
     2    0.000    0.000    0.000    0.000 <string>:12(__new__)
     1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
     1    0.000    0.000    0.001    0.001 _methods.py:28(_amin)
     4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
 22/16    0.000    0.000    0.002    0.000 chunk.py:122(read)
     2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
     6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
     6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
     2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
     2    0.000    0.000    0.143    0.071 fftpack.py:1013(rfftn)
     1    0.000    0.000    0.074    0.074 fftpack.py:1142(irfftn)
     2    0.000    0.000    0.139    0.070 fftpack.py:291(rfft)
     1    0.003    0.003    0.071    0.071 fftpack.py:380(irfft)
     3    0.007    0.002    0.200    0.067 fftpack.py:47(_raw_fft)
     3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
     3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2275(amin)
     3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
     1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
     3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
     1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
     1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
     2    0.000    0.000    0.034    0.017 version6.py:21(LoadWaveFile)
     1    0.786    0.786    1.169    1.169 version6.py:41(SaveWaveFile)
     1    0.005    0.005    0.227    0.227 version6.py:51(FFTConvolve)
     1    0.000    0.000    0.000    0.000 version6.py:64(<listcomp>)
     2    0.000    0.000    0.000    0.000 version6.py:65(<genexpr>)
     1    0.020    0.020    0.022    0.022 version6.py:76(Normalize)
     1    0.001    0.001    1.549    1.549 version6.py:85(Main)
     2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
     2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
     2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
     4    0.000    0.000    0.000    0.000 wave.py:188(close)
     4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
     4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
     4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
     2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
     2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
     2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
     2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
     2    0.000    0.000    0.002    0.001 wave.py:233(readframes)
     2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
     1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
        1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
        1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
        1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.003    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7fe951b179a0}
  1973509    0.241    0.000    0.241    0.000 {built-in method _struct.pack}
       12    0.032    0.003    0.032    0.003 {built-in method _struct.unpack_from}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000    1.564    1.564 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.max}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.113    0.008    0.113    0.008 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.061    0.061    0.061    0.061 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.103    0.052    0.103    0.052 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.029    0.029    0.029    0.029 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.003    0.003    0.003    0.003 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.135    0.000    0.135    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.002    0.000    0.002    0.000 {method 'read' of '_io.BufferedReader'
objects}
        2    0.002    0.001    0.002    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```

Teresa Van
10149274
CPSC 501 Assignment #4

8. Profile result after compiler level optimization:

```
3947382 function calls (3947376 primitive calls) in 1.494 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1    0.015    0.015    1.494    1.494 <string>:1(<module>)
     2    0.000    0.000    0.000    0.000 <string>:12(__new__)
     1    0.000    0.000    0.001    0.001 _methods.py:25(_amax)
     1    0.000    0.000    0.001    0.001 _methods.py:28(_amin)
     4    0.000    0.000    0.000    0.000 chunk.py:117(tell)
 22/16    0.000    0.000    0.002    0.000 chunk.py:122(read)
     2    0.000    0.000    0.000    0.000 chunk.py:145(skip)
     6    0.000    0.000    0.000    0.000 chunk.py:52(__init__)
     6    0.000    0.000    0.000    0.000 chunk.py:78(getname)
     2    0.000    0.000    0.000    0.000 chunk.py:98(seek)
     2    0.000    0.000    0.132    0.066 fftpack.py:1013(rfftn)
     1    0.000    0.000    0.072    0.072 fftpack.py:1142(irfftn)
     2    0.000    0.000    0.128    0.064 fftpack.py:291(rfft)
     1    0.003    0.003    0.068    0.068 fftpack.py:380(irfft)
     3    0.006    0.002    0.187    0.062 fftpack.py:47(_raw_fft)
     3    0.000    0.000    0.000    0.000 fftpack.py:613(_cook_nd_args)
     3    0.000    0.000    0.000    0.000 fftpack.py:95(_unitary)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2174(amax)
     1    0.000    0.000    0.001    0.001 fromnumeric.py:2275(amin)
     3    0.000    0.000    0.000    0.000 helper.py:257(put_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:283(pop_twiddle_factors)
     3    0.000    0.000    0.000    0.000 helper.py:311(_prune_cache)
     1    0.000    0.000    0.000    0.000 helper.py:53(next_fast_len)
     3    0.000    0.000    0.000    0.000 numeric.py:463(asarray)
     1    0.000    0.000    0.000    0.000 numerictypes.py:660(issubclass_)
     1    0.000    0.000    0.000    0.000 numerictypes.py:728(issubdtype)
     2    0.000    0.000    0.036    0.018 version6.py:21(LoadWaveFile)
     1    0.731    0.731    1.112    1.112 version6.py:41(SaveWaveFile)
     1    0.004    0.004    0.213    0.213 version6.py:51(FFTConvolve)
     1    0.000    0.000    0.000    0.000 version6.py:64(<listcomp>)
     2    0.000    0.000    0.000    0.000 version6.py:65(<genexpr>)
     1    0.020    0.020    0.022    0.022 version6.py:76(Normalize)
     1    0.000    0.000    1.479    1.479 version6.py:85(Main)
     2    0.000    0.000    0.000    0.000 wave.py:125(initfp)
     2    0.000    0.000    0.000    0.000 wave.py:156(__init__)
     2    0.000    0.000    0.000    0.000 wave.py:169(__del__)
     4    0.000    0.000    0.000    0.000 wave.py:188(close)
     4    0.000    0.000    0.000    0.000 wave.py:198(getnchannels)
     4    0.000    0.000    0.000    0.000 wave.py:201(getnframes)
     4    0.000    0.000    0.000    0.000 wave.py:204(getsampwidth)
     2    0.000    0.000    0.000    0.000 wave.py:207(getframerate)
     2    0.000    0.000    0.000    0.000 wave.py:210(getcomptype)
     2    0.000    0.000    0.000    0.000 wave.py:213(getcompname)
     2    0.000    0.000    0.000    0.000 wave.py:216(getparams)
     2    0.000    0.000    0.002    0.001 wave.py:233(readframes)
     2    0.000    0.000    0.000    0.000 wave.py:254(_read_fmt_chunk)
     1    0.000    0.000    0.001    0.001 wave.py:291(__init__)
```

Teresa Van
10149274
CPSC 501 Assignment #4

```
        1    0.000    0.000    0.000    0.000 wave.py:303(initfp)
        1    0.000    0.000    0.000    0.000 wave.py:315(__del__)
        1    0.000    0.000    0.000    0.000 wave.py:327(setnchannels)
        1    0.000    0.000    0.000    0.000 wave.py:339(setsampwidth)
        1    0.000    0.000    0.000    0.000 wave.py:351(setframerate)
        1    0.000    0.000    0.000    0.000 wave.py:363(setnframes)
        1    0.000    0.000    0.000    0.000 wave.py:371(setcomptype)
        1    0.000    0.000    0.000    0.000 wave.py:385(setparams)
        1    0.000    0.000    0.002    0.002 wave.py:413(writeframesraw)
        1    0.000    0.000    0.002    0.002 wave.py:426(writeframes)
        2    0.000    0.000    0.004    0.002 wave.py:431(close)
        2    0.000    0.000    0.000    0.000 wave.py:449(_ensure_header_written)
        1    0.000    0.000    0.000    0.000 wave.py:459(_write_header)
        1    0.000    0.000    0.000    0.000 wave.py:480(_patchheader)
        3    0.000    0.000    0.001    0.000 wave.py:492(open)
        2    0.000    0.000    0.000    0.000 {built-in method __new__ of type object at
0x7f04bb6b39a0}
  1973509    0.240    0.000    0.240    0.000 {built-in method _struct.pack}
       12    0.034    0.003    0.034    0.003 {built-in method _struct.unpack_from}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.abs}
        1    0.000    0.000    1.494    1.494 {built-in method builtins.exec}
        4    0.000    0.000    0.000    0.000 {built-in method builtins.isinstance}
        2    0.000    0.000    0.000    0.000 {built-in method builtins.issubclass}
       51    0.000    0.000    0.000    0.000 {built-in method builtins.len}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.max}
        1    0.000    0.000    0.000    0.000 {built-in method builtins.round}
        3    0.001    0.000    0.001    0.000 {built-in method io.open}
       15    0.112    0.007    0.112    0.007 {built-in method numpy.core.multiarray.array}
        3    0.000    0.000    0.000    0.000 {built-in method numpy.core.multiarray.zeros}
        1    0.059    0.059    0.059    0.059 {built-in method numpy.fft.fftpack_lite.rfftb}
        2    0.094    0.047    0.094    0.047 {built-in method numpy.fft.fftpack_lite.rfftf}
        1    0.027    0.027    0.027    0.027 {built-in method numpy.fft.fftpack_lite.rffti}
        3    0.000    0.000    0.000    0.000 {method 'append' of 'list' objects}
       71    0.000    0.000    0.000    0.000 {method 'bit_length' of 'int' objects}
        2    0.000    0.000    0.000    0.000 {method 'close' of '_io.BufferedReader'
objects}
        1    0.004    0.004    0.004    0.004 {method 'close' of '_io.BufferedWriter'
objects}
        1    0.002    0.002    0.002    0.002 {method 'copy' of 'numpy.ndarray' objects}
        1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'
objects}
  1973505    0.135    0.000    0.135    0.000 {method 'extend' of 'bytearray' objects}
        1    0.000    0.000    0.000    0.000 {method 'flush' of '_io.BufferedWriter'
objects}
        5    0.000    0.000    0.000    0.000 {method 'pop' of 'collections.OrderedDict'
objects}
        2    0.000    0.000    0.000    0.000 {method 'pop' of 'list' objects}
       20    0.001    0.000    0.001    0.000 {method 'read' of '_io.BufferedReader'
objects}
        2    0.002    0.001    0.002    0.001 {method 'reduce' of 'numpy.ufunc' objects}
        2    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'seek' of '_io.BufferedWriter'
objects}
        2    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedReader'
objects}
        3    0.000    0.000    0.000    0.000 {method 'tell' of '_io.BufferedWriter'
objects}
        6    0.002    0.000    0.002    0.000 {method 'write' of '_io.BufferedWriter'
objects}
```