



**CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY**

Name(s) Eric A. Ford	Project Number S1507
Project Title Music to My Ears: A Fourier Analysis of Sounds Produced by Acoustic and Digital Pianos	
Objectives/Goals My objective was to determine if a distinction could be made between music played on an acoustic piano and the same music played on a digital piano using Fourier analysis. I hypothesized that when examining the Fourier transforms, a difference could be perceived between the recordings from the two piano types because the instruments should produce different frequency patterns, even though the musical pieces played were identical.	
Abstract Methods/Materials I used samples of a single musical composition that was recorded on both acoustic and digital pianos, each manufactured by a different company. The recordings were produced in a consistent manner, under similar conditions. Five acoustic pianos and five digital pianos, all of which were professional quality instruments, were included in my study. I converted all the recordings from MP3 format to WAV format to be able to conduct a Fast Fourier Transform (FFT) using Matlab. By issuing a series of commands to normalize the data and calculate and plot the FFTs in the frequency domain, I produced graphs that display the energy of the frequencies. In addition to analyzing the full composition, I isolated a single note from each sample to narrow my field of comparison. I studied the resulting plots to determine if differences in patterns of the frequencies could be found between the sounds produced on the acoustic and the digital pianos.	
Results While the plots of the FFTs of each sample differed from every other plot, similarities existed between the acoustic and digital piano types. FFT plots display a single frequency peak and its harmonics. Harmonics are vibrations of the strings at octaves higher than the fundamental tone, thus adding higher frequencies to the sound. In the analysis of a single note, the acoustic pianos produced more harmonics than the digital pianos. The harmonics of the acoustic pianos also had higher amplitudes or relative energies.	
Conclusions/Discussion I concluded that a distinction between sounds produced by acoustic and digital pianos can be made using Fourier analysis due to the greater number of harmonics produced by the acoustic pianos. The digital pianos also produce harmonics, but not to the same extent as the acoustic pianos. Therefore, despite the fact that digital pianos create sound by reproducing samples of sounds created on acoustic pianos, digital pianos do not produce the same quality of sound as that of the acoustic instruments.	
Summary Statement My project determines whether an audio recording of a musical composition played on an acoustic piano can be distinguished from an audio recording of the same musical composition played on a digital piano using Fourier analysis.	
Help Received Dr. Alan Van Nevel, Mr. Peter Wiley, and Mr. Nick Bling of the Naval Air Weapons Station at China Lake guided me in the use of Matlab and answered my questions about Fourier analysis. My father helped with the use of Matlab and both my parents assisted with the arrangement of my display.	