Firework Hearing Loss

New Mexico
Supercomputing Challenge
Final Report
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Team 23
Creative Education Preparatory Institute #1

Team Members
Arlene Pino
Angela Caudle
Chance Lammey

Teachers
Jerry Esquivel
James Stewart

Project Mentors
Mark Murmer
Judith Velarde
Laura Rowen

Executive Summary

In this project, we examined a problem that affects many Americans and simulated it without causing any more damage. The National Institute on Deafness and Other Communication Disorders (NIDCD) estimates that approximately 15 percent (26 million) of Americans between the ages of 20 and 69 have high frequency hearing loss due to exposure to loud sounds or noise at work or in leisure activities. Our project's goal was to simulate the damage at different distances without actually hurting another person's hearing. We have a model that measures the decibels being emitted from a firecracker as it passes a person, as well as data from a physical experiment. We also have research on the number of decibels needed to cause serious damage. We measured the collected data against our findings to determine that decibel ratings are not higher the closer a person is to the source, and in return, so is the risk potential to damage a person's hearing.

Definition of the Problem

As we all know, fireworks also produce a loud noise that may hurt the ears of some people. Our problem deals with the damage to the ear drum due to the intensity of that firework blast. Approximately 4,000 new cases of sudden deafness occur each year in the United States, and this deafness affects only one ear in the nine out of 10 people who experience it. Only 10 to 15 percent of patients with sudden deafness know what caused their loss. Approximately 17 percent (36 million) of American adults report some degree of hearing loss. Of adults ages 65 and older in the United States, 12.3 percent of men and nearly 14 percent of women are affected by tinnitus. Tinnitus is identified more frequently in white individuals, and the prevalence of tinnitus is almost twice as frequent in the South as in the Northeast. Because of the prevalence of hearing loss, we decided to simulate the damaging effects of firecracker blasts.

Our experiment's goal was to measure the intensity of a firework blast, and then take that data and use it in comparison to hearing damage. Our project demonstrated the effects a firecracker can have on a person's hearing at different distances.

Solving the Problem

To solve our problem, we began with a pre-made Net Logo model. This model was used to measure the amplitudes of the sound waves given off by a jet as it passed by a person. We call this person our “Listener.” As the waves pass the Listener, the values are plotted on a line graph. The model also allowed you to change the speed of the jet. This way we could show, in the graph, how the amplitudes changed as the jet got closer to the Listener.

Our task required us to change the Net Logo model to fit our problem. First, we changed the jet to a “fir” (our version of a firecracker). Then we changed the commands from “plane” to “fir” so that the program would work with our new object. We then changed the measurement to decibels instead of amplitude. Once we completed those alteratiopns, we had to fix a few numbers in the calculations. After those changes were made, our model ran without any problems.

In addition to our model, we also conducted a physical experiment. We used three high-tech microphones made specifically to measure sound pressure. The microphones were connected to an interface that, in turn, was connected to a laptop. The laptop had Vernier software that would graph the results gathered from the microphones. We then set up the microphones three inches, five feet, and 10 feet from the firecracker. After we had our testing area set up, we detonated our firecrackers several times. We also have runs from the separate distances to compare them to each other.

To finish our data, we used an online converter to change the sound pressure ratings that the experiment found into decibel ratings.

Our Code

```
breed [ firs fir ]

breed [ listeners listener ]

breed [ wave-components wave-component ]


wave-components-own [

  decibels

  wave-id ;; the wave-id identifies which wave this

        ;; component is a part of

]


listeners-own [

  wave-ids-heard ;; which wave-ids the listener just heard

               ;; computed to avoid double-counting

]


globals [

  speed-of-sound  ;; constant

  next-wave-id ;; counters
```

```
  wave-interval ;; how many ticks between each wave?
  initial-wave-decibels
]

to setup
  ca
  set-default-shape wave-components "wave particle"
  set-default-shape firs "fir"
  set-default-shape listeners "person"

  set speed-of-sound 757
  set initial-wave-decibels 140
  set wave-interval 3

  ;; initialize counters
  set next-wave-id 0

  ;; create the fir
  create-firs 1 [
    set heading 90
```

```
    set ycor 3 + min-pycor


    set xcor 14 + min-pxcor

    set size 2

  ]


  ;; create the listener

  create-listeners 1 [

    set size 3

    set color green

  ]

end


to go

  ask firs [ fd 1 * fir-speed / speed-of-sound ]      ;; move the fir

  if ticks mod wave-interval = 0 [ ask firs [ emit-wave ] ] ;; emit the sound
wave

  ;; move waves

  ask wave-components [

    if not can-move? 1 [ die ]
```

```
  fd 1
  set decibels decibels - 1
  set color scale-color yellow decibels 0 initial-wave-decibels
  if decibels < 1 [ die ]
]

;; listen and plot
ask listeners [
  let amp decibels-here wave-ids-heard
  plotxy ticks amp
  plotxy (ticks + 0.5) 0
  set wave-ids-heard
    remove-duplicates
      [ wave-id ] of wave-components-here

  ]

  ;; show the wave and paint patches black
  ask wave-components [ st ]
   ask patches with [ pcolor != gray ] [
```

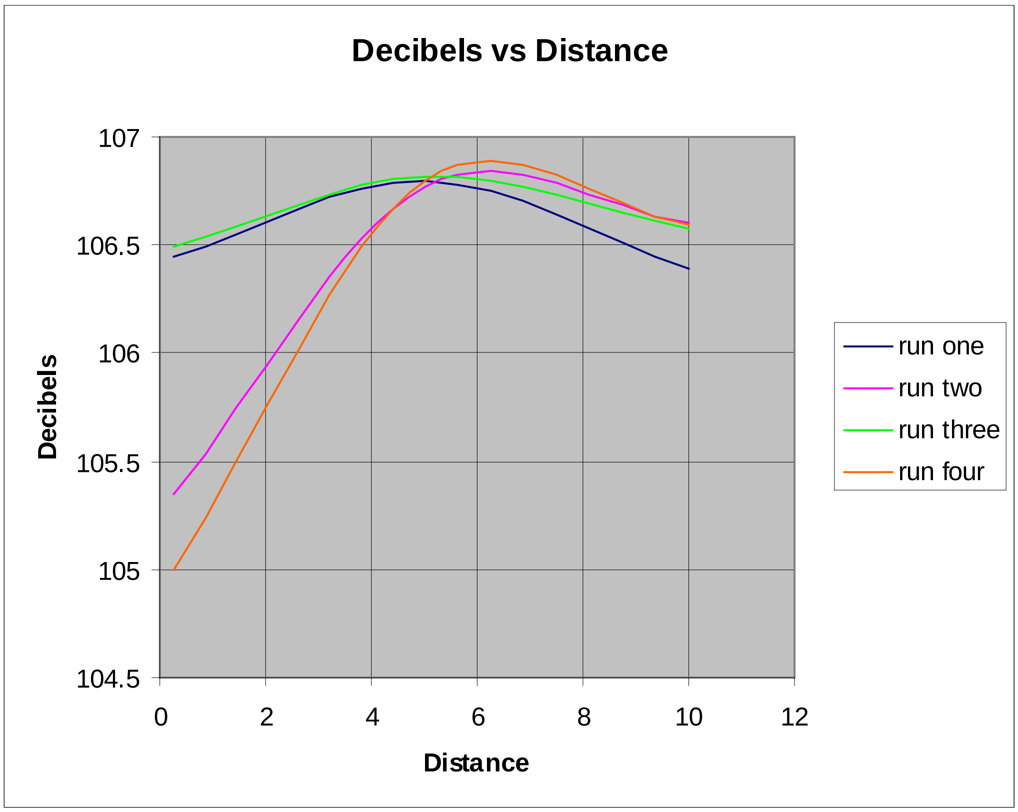
```
      set pcolor black
      set plabel ""
    ]

  tick
end

;; patch procedure
;; counts the total decibels of the waves on this patch,
;; making sure not to count two components of the same wave.
to-report decibels-here [ids-to-exclude]
  let total-decibels 0  ; set to 0 IXI
  let components wave-components-here
  if count components > 0 [
    ;; get list of the wave-ids with components on this patch
    let wave-ids-here remove-duplicates [ wave-id ] of components
    foreach ids-to-exclude [ set wave-ids-here remove ? wave-ids-here ]

    ;; for each wave id, sum the maximum decibels here
```

```
    foreach wave-ids-here [ set total-decibels total-decibels +
      [decibels] of max-one-of components with [ wave-id = ? ]
        [ decibels ]
    ]
  ]
  report total-decibels
end

;; fir procedure
to emit-wave
  let j 0
  let num-wave-components 90 ;; number of components in each wave
  hatch-wave-components 360 [
    set color yellow
    set size 1
    set j j + 1
    set decibels initial-wave-decibels
    set wave-id next-wave-id
    set heading j * ( 360.0 / num-wave-components )
```

```
  ]
  set next-wave-id next-wave-id + 1
end

;; reports the fir speed in Mach, or
;; number of times the speed of sound
to-report mach
  report fir-speed / speed-of-sound
end
```

Results

Our results show that the decibel rating does not peak the closer you are to an object.



On our first run, we found that the decibel rating was 106.442 dB (4.199 Pa) at three inches; the five-foot microphone was exposed to 106.799 dB (4.375 Pa); the 10-foot microphone registered a 106.388 dB rating (4.173 Pa).

On our second run, we found that the decibel rating was 105.351 dB (3.703 Pa) at three inches; the five-foot microphone was exposed to 106.773 dB (4.362 Pa); the 10-foot microphone registered a 106.602 dB rating (4.277 Pa).

On our third run, we found that the decibel rating was 106.496 dB (4.225 Pa) at three inches; the five-foot microphone was exposed to 106.811 dB (4.381 Pa); the 10-foot registered a 106.576 dB rating (4.264 Pa).

On our fourth run, we found that the decibel rating was 104.994 dB (3.554 Pa) at three inches; the five-foot microphone was exposed to 106.799 dB (4.375 Pa); the 10-foot registered a 106.590 dB rating (4.271 Pa).

Conclusion

After analyzing the data we have collected, we have disproved our hypothesis. Our hypothesis had stated that the farther away from the firecracker, the lower the decibel rating would be. In the course of our study, we have found that the rating is low when the microphone was next to it, higher at five feet, and then dropped again at 10 feet. These findings show that the hearing loss is greatest at about a five-foot distance from a firecracker. This conclusion leads us to believe we may have a significant margin of error. Our microphones should have been at the same height as the fuse. We believe that the microphones did not pick up an accurate reading because they were positioned lower than the sound origin.

Personal Achievements

Arlene Pino

My biggest personal achievement that came from this project was everything that I was able to learn. I learned lots of math and science that I have been able to use in my everyday schoolwork. I am currently studying Physics and, by using the high tech microphones, I was better able to better understand the behavior of sound waves as opposed to light waves. This experience also has helped me in my Algebra II class. It showed me how to solve a real-life problem (i.e., a word problem) using a model.

Angela Caudle

I believe that my biggest achievement during this project was my ability to write technically. I was forced into a type of writing that I was unfamiliar to me, and it helped to broaden my writing abilities. I usually write only fictional narratives and this project has helped prepare me for my senior research project next year. I believe that I have been able to take this assignment and make the most of it. I now (almost) enjoy writing research reports.

Chance Lammey

The biggest achievement I gained during this project was using math and science that I normally do not use. This was a good opportunity to sharpen these skills. Another thing I found beneficial and interesting was using the high-tech microphones to detect the certain sound waves.

Acknowledgments

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