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APPENDICES

Appendix A Materials Relating to the Triangle Pilot Test

A.1. Overview

This appendix contains material used in the Triangle Pilot test. These materials include the Informed Consent form, the Background Survey, the Pre-test, Main test, the answer sheet used to record responses, and Triangle screen images demonstrating the testing environment. Finally, there is a summary of the results from this pilot test.

A.2. Informed Consent Form

Physics Department, Oregon State University

Title of Project: A Comparison Between Auditory and Visual Graphing Methods.

Investigators: Steven Sahyun, Graduate Research Assistant, Physics Department
John Gardner, Professor, Physics Department

This purpose of this study is to determine whether auditory graphing (data representation using sound) is comparable to visually displayed graphs. In particular, this study will be examining how well conclusions can be drawn from auditory graphs vs. visually displayed graphs.

This study involves three parts, a survey, a pre-test, and a main test. The survey is to find out information on factors which may affect your knowledge of graphical material. The pre-test is to find out information on basic graph interpretation skills. The main test will be similar to the pre-test except that there will be more questions. The main test will involve viewing a computer monitor, and possibly listening to sounds generated by the computer. If there are sounds involved, you will be able control the sound volume to a level that you are comfortable with.

Any information obtained from this study will be kept confidential. A code number will be used to identify any test results or other information that is provided. The only people who will have access to this information will be the investigators and no names will be used in any data summaries or publications. For subjects volunteering from a physics course, participation in this study will result in credit towards one laboratory class, as determined by your instructor, but results from the study will not be used to determine credit.

Participation in this study is voluntary and you may either refuse to participate or withdraw from the study at any time. You may stop the study at any time or take a break. However, only completed tests will be used in the study and receive full credit.

If you have any questions about the research study and/or specific procedures, please contact Steven Sahyun, Physics Department, 301 Weniger Hall; the phone number is 737-1712. Any other questions should be directed to Mary Nunn, Sponsored Programs Officer, OSU Research Office, 737-0670.

My signature below indicates that I have read and that I understand the procedures described above and give my informed and voluntary consent to participated in this study. I understand that I will receive a signed copy of this consent form.

_____	_____	_____
Signature of subject (or subject's legally authorized representative	Name of Subject	Date signed
_____		_____
Signature of Investigator		Date signed

A.3. Survey

Survey: Background Information:

1. Gender: M F

2. Age:

3. Have you taken a high school physics course? Y N

4. Number of years of college level physics: 0 1 2 3 4 5+

5. Have you taken courses other than physics where graphed data was important?
   Y N
   If yes, please describe:

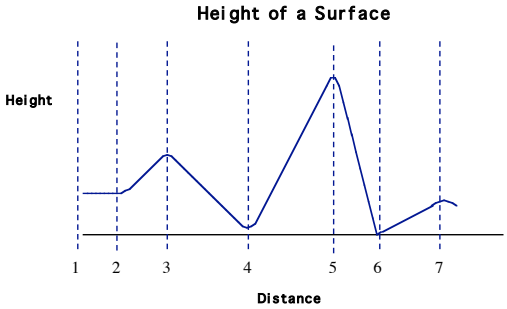
6. Have you learned graphing techniques other than from academic settings?

7. If you have had any musical training, please describe instrument or field and length of time of study:

8. Do you have any difficulties (i.e. vision or hearing) that may affect your ability to receive information?

A.4. Pre-test

Questions 9 - 12 refer to the following graph describing the profile of a surface; the y-axis represents height and the x-axis represents distance.



9. How many relative maxima (locations where a point has a greater y-axis value than the points to either side) are there?

0 1 2 3 4 5 6 7

10. The absolute maximum (greatest y value) is at which point?

1 2 3 4 5 6 7

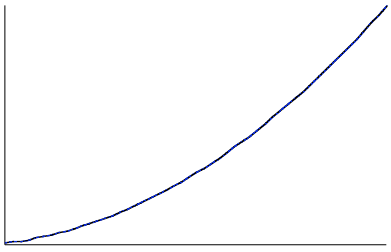
11. The absolute minimum (lowest y value) is at which point?

1 2 3 4 5 6 7

12. The largest magnitude slope (greatest change in y for a change in x) occurs where?

A)	Between points 1 and 2.	D)	Between points 4 and 5.
B)	Between points 2 and 3.	E)	Between points 5 and 6.
C)	Between points 3 and 4.	F)	Between points 6 and 7.

13. The following graph is of an object's motion. The y-axis represents the object's distance, and the x-axis represents time.



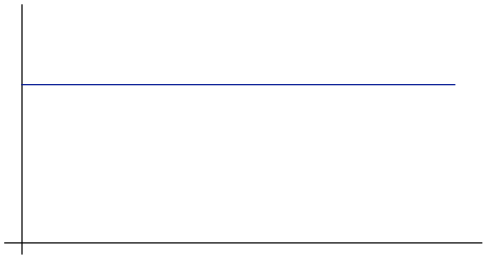
Which sentence is the best interpretation of this graph(please circle answer)?

A) The object is moving with a constant, non-zero acceleration.
B) The object does not move.
C) The object is moving with a linearly increasing velocity.
D) The object is moving with a constant velocity.
E) The object is moving with a decreasing acceleration.

A.5. Main Test

Question 1:

This is a graph of an object's motion. The y-axis represents the object's distance, and the x-axis represents time.

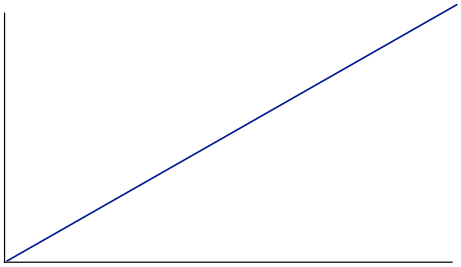


Which sentence is the best interpretation of this graph?

A) The object is moving with a constant non-zero acceleration.
B) The object does not move.
C) The object is moving with a uniformly increasing velocity.
D) The object is moving with a constant velocity.
E) The object is moving with a uniformly increasing acceleration.

Question 2:

This is a graph of an object's motion. The y-axis represents the object's distance, and the x-axis represents time.

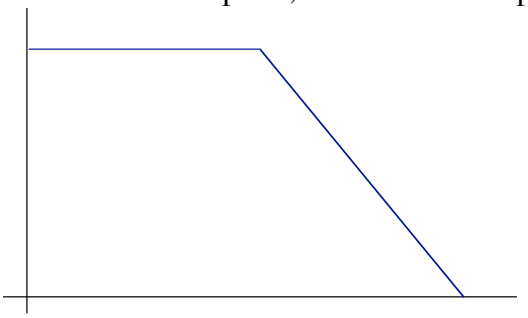


Which sentence is the best interpretation of this graph?

A) The object is moving with a constant non-zero acceleration.
B) The object does not move.
C) The object is moving with a uniformly increasing velocity.
D) The object is moving with a constant velocity.
E) The object is moving with a uniformly increasing acceleration.

Question 3:

This is a graph of an object's motion. The y-axis represents the object's displacement from a reference point, and the x-axis represents time.

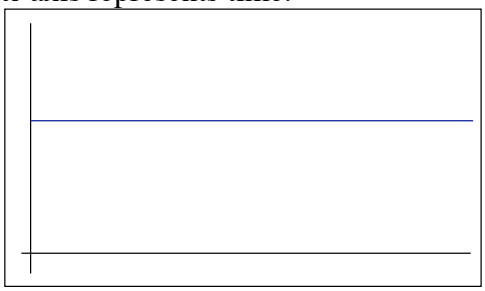


Which sentence is the best interpretation?

A) The object rolls along a flat surface. Then it rolls down a hill, and then finally stops.
B) The object doesn't move at first. Then it rolls down a hill and finally stops.
C) The object is moving at a constant velocity. Then it slows down and stops.
D) The object travels along a flat area, moves down a hill toward the reference point and then keeps moving.
E) The object doesn't move at first. Then it moves towards the reference point and then finally stops.

Question 4:

This is a graph of an object's motion. The y-axis represents the object's velocity, and the x-axis represents time.

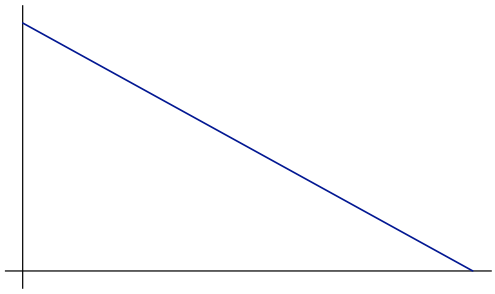


Which sentence is the best interpretation of the object's motion?

A) The object is moving with constant acceleration.
B) The object is moving with uniformly decreasing acceleration.
C) The object is moving with uniformly increasing velocity.
D) The object is moving at a constant velocity.
E) The object does not move.

Question 5:

This is a graph of an object's motion. The y-axis represents the object's velocity, and the x-axis represents time.

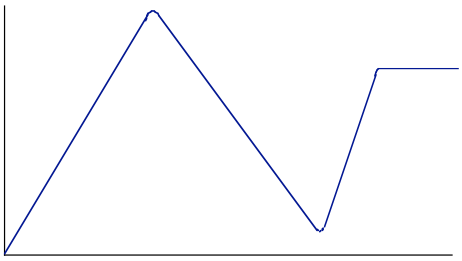


Which sentence is the best interpretation of the object's motion?

A) The object is moving with a constant acceleration.
B) The object is moving with a decreasing acceleration.
C) The object is moving with uniformly increasing velocity.
D) The object is moving at a constant velocity.
E) The object does not move.

Question 6:

This is a graph of an object's motion. The y-axis represents the object's velocity, and the x-axis represents time.

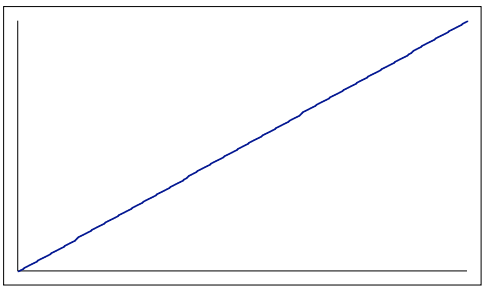


Locate the part of the graph when the acceleration is greatest.

A) Before the maximum velocity.
B) Between the maximum velocity and the next (occurring at a later time) minimum velocity.
C) Between the local minimum and the constant velocity region.
D) During the constant velocity region.
E) The acceleration is never greatest.

Question 7:

The following graph concerns the kinetic energy of a falling ball. The y-axis represents the kinetic energy and the x-axis represents the distance that the ball has fallen.

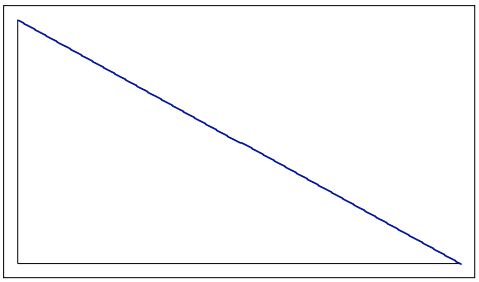


Which sentence is the best interpretation of the graph?

A) The kinetic energy of the ball remains constant.
B) The kinetic energy is increasing linearly with distance.
C) The kinetic energy increases as the square of the distance.
D) The total energy of the ball remains constant.
E) The kinetic energy is decreasing linearly with distance.

Question 8:

The following graph concerns the gravitational potential energy of a falling ball. The y-axis represents the potential energy and the x-axis represents the distance that the ball has fallen.

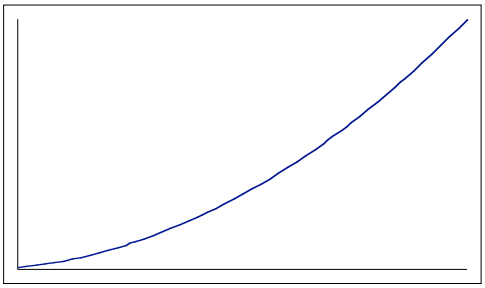


Which sentence is the best interpretation of the graph?

A) The gravitational potential energy of the ball remains constant.
B) The total energy of the ball remains constant.
C) The gravitational potential energy is increasing linearly with distance.
D) The gravitational potential energy increases as the square of the distance.
E) The gravitational potential energy is decreasing linearly with distance.

Question 9:

The following graph is for the elastic potential energy of a spring. The y-axis represents the potential energy of the spring, and the x-axis represents the distance that the spring is compressed.

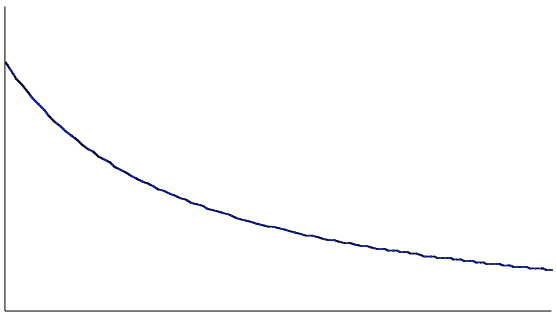


Which sentence is the best interpretation of the graph?

A) The elastic potential energy increases as the square of the distance that the spring is compressed.
B) The elastic potential energy is increasing linearly with the distance the spring is compressed.
C) The elastic potential energy of the spring remains constant.
D) The total energy of the spring remains constant.
E) The elastic potential energy is decreasing.

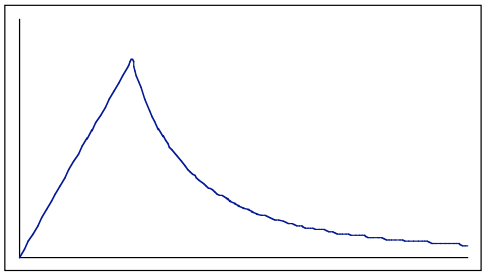
Question 10:

The following graph relates frequency of light to its wavelength. The y-axis represents frequency of light and the x-axis represents the wavelength.



Which sentence is the best interpretation from the graph?
A) The frequency increases linearly with wavelength.
B) The frequency decreases linearly with wavelength.
C) The frequency is proportional to 1 / wavelength.
D) The frequency is constant with the wavelength.
E) The frequency is not related to the wavelength.

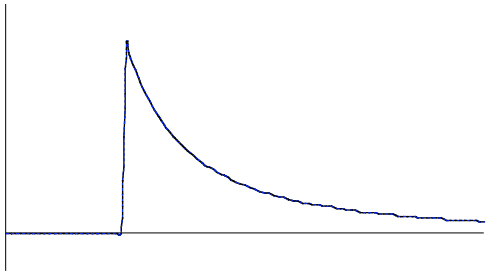
Question 11:
The following graph refers to the gravitational force produced by a solid, uniformly dense sphere acting on a test mass m. The y-axis represents the gravitational force, and the x-axis represents the distance from the center of the sphere.



Which sentence is the best interpretation from the graph?
A) The gravitational force increases linearly with distance.
B) The gravitational force decreases linearly with distance.
C) The gravitational force first increases linearly, then decreases linearly.
D) The gravitational force first increases linearly, then is proportional to 1 / (distance)^2.
E) The gravitational force is not related to the distance.

11b. What does the peak on the graph represent?

Question 12:
The following graph refers to the electric field produced by a charged spherical shell. The y-axis represents the Electric Field, and the x-axis represents the distance from the center of the sphere.

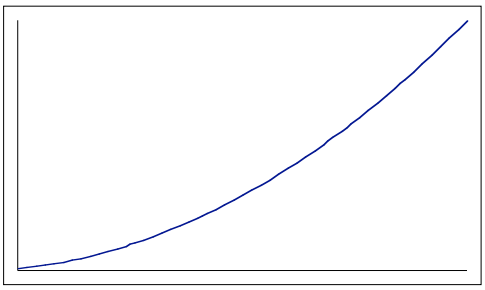


Which sentence is the best interpretation from the graph?
A) The electric field first increases linearly, then decreases linearly.
B) The electric field is zero, then is proportional to 1 / (distance)^2.
C) The electric field increases linearly with distance.
D) The electric field decreases linearly with distance.
E) The electric field is not related to the distance.

12b. What does the peak on the graph represent

Question 13:

The following graph represents the deflection of an electron traveling through an electric field produced by two parallel plates. The electron enters with an initial velocity v_0 and travels from the left to the right. The y-axis represents the distance in the y direction that the electron has traveled, and the x-axis represents the distance traveled in the x direction.



Which sentence best describes the path of the electron?
A) The electron passes through undeflected.
B) The electron is deflected by a linearly increasing distance while between the plates.
C) The electron is deflected proportional to $(\text{distance})^2$ while between the plates.
D) The electron is deflected by a linearly decreasing distance while between the plates.
E) The electron does not pass between the plates.

Question 14:

When water depth is greater than three wavelengths, the speed of ocean waves in water is approximated by the following graph, where the y-axis represents the velocity of ocean waves and the x-axis represents the wavelength.

Which sentence is the best interpretation from the graph?
A) The speed of ocean waves is proportional to √(wavelength).
B) The speed of ocean waves increases linearly with the wavelength.
C) The speed of ocean waves is proportional to (wavelength)2.
D) The speed of ocean waves decreases linearly with the wavelength.
E) The speed is not dependent on the wavelength.

A.6. Answer Sheet

Please mark your answers of the graph test on this page. For multiple-choice questions, please circle the appropriate letter, for short answer questions (11b and 12b) please write your answer on the space provided. If you have any additional comments about the question, please write a note in the area to the right of the answer.

	Answer:					Additional comments:
1.	A	B	C	D	E	
2.	A	B	C	D	E	
3.	A	B	C	D	E	
4.	A	B	C	D	E	
5.	A	B	C	D	E	
6.	A	B	C	D	E	
7.	A	B	C	D	E	
8.	A	B	C	D	E	
9.	A	B	C	D	E	
10.	A	B	C	D	E	
11.	A	B	C	D	E	
11b.						.
12.	A	B	C	D	E	
12b.						.
13.	A	B	C	D	E	
14.	A	B	C	D	E	

A.7. Screen Image of the TRIANGLE program

This is an image of the screen that was seen by the subjects during the Triangle pilot test. The Sound group had the lower right corner of the screen covered so that they were unable to view the graph.

Figure A.7.1. Screen Image of the Triangle Program.

A.8. Summary of Results from Triangle Pilot Test

Appendix B Material Relating to the Web Pilot Test

B.1. Overview

This appendix contains material used in the Web Pilot test. These materials include the Introductory page and Informed Consent form, the Background Survey, the Pre-test, and Main test Web pages demonstrating the testing environment. The test questions were similar to those used in the Triangle Pilot test shown in Appendix A. There is a tabulated summary of the results obtained from the Web Pilot test in section B6. Finally, there is a brief analysis of the distribution of test scores.

B.2. Introductory Page and Informed Consent Form

Welcome

The object of this test is to compare students' ability to answer questions from data contained in graphical formats. Two types of graphs are utilized, pictorial graphs which almost everyone is familiar with, and sonified data graphs (data represented by sound), which is much less common. For the pictorial graphs, you will need a web browser such as Netscape or Explorer which can display .gif images. An example of such an image is the following:

The sonified data will be available in several sound formats: QuickTime, MIDI, and .wav files. The QuickTime .mov files are embedded in the pages and appear as a gray bar with controls. After these bars are links to midi and .wav files for downloading. QuickTime is the recommended format as it will be displayed on each page and is most convenient to use. The midi files are small (2 Kb) while the equivalent .wav files are large (about 130 Kb) and take a longer time to load. To hear the sound graphs you will need a multi-media computer capable of generating the sounds, such as a PC with a sound card, or a Mac; and the appropriate software. To listen to the QuickTime files, you will need Apple's QuickTime plug-in for your web browser. The following is a sample sound graph. Please make sure you can hear this graph before taking the test.

 MIDI WAV

If you do not see a bar above this line, and if QuickTime is installed, there may have a conflict with is your browser, if this is the case try reloading the page. If you do see the control bar, click on the "play" arrow to listen to the graph. The slider bar gives an indication of how much time has elapsed, you can move the slider to any point in the graph and play from that point.

To listen to the graph as a midi file, click on the MIDI link above; your browser should be configured to automatically start a midi player to listen to the file. You can also download the file by shift-clicking on the link. To listen to the graph as a .wav file, click on the WAV link above; again, your browser should be configured to automatically start a sound player after the file has downloaded. If you can hear the QuickTime graph then you do not need to use these links.

The Y axis of the sound graph is represented by pitch and the X axis is represented by time. The second derivative, or the rate at which the graph is increasing or decreasing is represented by the background "clicks." Play the graph several times and match the sound graph to the picture above.

Go to the Sonitypes Page.

The Sonitypes Page contains a more detailed explanation and basic examples of the sound graphs. Please follow this link to become more acquainted with the basic graph types that will be used in the test. Return here after listening to the graphs.

Statement of Informed Consent

Physics Department, Oregon State University

Title of Project: Comparison Between Auditory and Visual Graphing Methods.

Investigators:
Steven Sahyun, Graduate Research Assistant, Physics Department.
John Gardner, Professor, Physics Department.

This purpose of this study, as stated above, is to determine whether auditory graphing (data representation using sound) is comparable to visually displayed graphs. In particular, this study will be examining how well conclusions can be drawn from auditory graphs vs. visually displayed graphs.

How the test will work:

The format for this test is divided into several parts. First subjects will be asked to give their name and a school code which is used to identify which testing group the student is from.

Next, a demographic survey will be presented to the subject for completion. This is to receive some indication of the subject's background and training. A Pre-test follows the survey and consists of five questions about two different graphs.

Finally, the subject is given a series of questions relating to physics and graphs. The questions are to be answered from the information contained within the graphs, although the subject matter is drawn from material that students are exposed to during a first-year general physics course at a typical college or university. Subjects will be randomly assigned to one of three groups. Those using picture graphs, those using sound graphs, and those using both sound and picture graphs (please listen to the graphs before answering the questions!) There will be 14 questions in the main test. Only data from subjects who answer all 14 test questions will be used.

It should be noted that all responses are being transferred on the Internet, and are not encrypted. However, reasonable attempts at confidentiality are made in that the subject's name will not appear with, or be stored with, any of their responses. Names will not be used in any publications or presentations of the data obtained.

It should also be noted that in cases where student subjects are taking this test for extra credit in a course, a list of which students have taken the test will be forwarded to the respective school's instructor so that those subjects may receive credit. Results of the study will not be used to determine credit. Also, a summary listing of the average responses to the test questions will be available to the instructor.

Participation in this study is voluntary and you may either refuse to participate or withdraw from the study at any time, although full participation is greatly appreciated.

If you have any questions about the research study and/or specific procedures, please contact:
Steven Sahyun
Physics Department
Oregon State University
301 Weniger Hall
Corvallis OR, 97330
USA
The phone number is (541) 737-1712. Any other questions should be directed to Mary Nunn, Sponsored Programs Officer, OSU Research Office, Oregon State University, Corvallis, OR, 97331. The phone number is: (541) 737-0670.

After reviewing and agreeing to the above procedure,

Start the test.

Questions about this test? Send me e-mail:
sahyuns@ucs.orst.edu

Last modified October 12, 1997.

B.3. Survey

The survey questions were similar to those used in the Triangle Pilot, but with slight modifications as noted in chapter 7. The survey utilized radio buttons and text box areas for selecting and typing responses. A screen shot of the survey is displayed in Figure B.3.1.

EMBED Word.Picture.8

Figure B.3.1. Screen Image of the Web Pilot Survey

B.4. Pre-test

The Web Pilot's pre-test text and images were the same as in the Triangle Pilot, but the layout of the Web page contained radio buttons for answer selection. The pre-test is displayed in Figure B.4.1.

Figure B.4.1 Screen image of the Pre-test.

B.5. Main Test

Figure B.5.1 is a screen image of a typical question page presented to the subjects. The subjects chose their answer via radio button selections. They were required to select one choice before the next question would be displayed. The questions were similar to those displayed in Appendix A but with the modifications as noted in Chapter 7.

Figure B.5.1 Screen image from the Web Pilot Main Test

B.6. Summary of Results from the Web Pilot Test

Tables B.6.1 and B.6.2 are summaries of the results obtained from the Web Pilot test. The tables are divided into four columns: All, Vision, Both, and Sound. The All category represents the average of all subjects taking the test, Vision represents the subjects given the test with visually presented graphs, Both represents the group given the test with both visual and auditory graphs, and Sound represents the subjects given the test with only auditory graphs.

Table B.6.1 contains the average scores for the test per group, as well as demographic information obtained from the survey. This information included the percentage of females taking the test, the average age, whether or not they had taken a physics course in high school, and whether or not they had taken previous physics courses.

Table B.6.1 . Summary of Results from the Web Pilot Test.

	Group			
	All	Vision	Both	Sound
Pre-test				
Avg.	4.14	4.27	4.00	4.23
std. dev.	0.94	0.89	0.98	0.96
Main test				
Avg.	8.04	9.29	9.18	5.65
std. dev.	3.55	3.21	3.26	2.91
Number of Subjects.	221	72	74	75
Gender %F	54%	60%	43%	59%
Avg. Age	21	21	21	21
H.S. Phys.	59%	63%	61%	53%
Coll. Phys.	16%	21%	15%	13%

Table B.6.2 Summary of Results from the Web Pilot Test, continued.

	% correct			
Question	All	Vision	Both	Sound
Pre-test				
P1	74%	77%	71%	78%
P2	97%	97%	97%	96%
P3	97%	99%	96%	95%
P4	80%	83%	78%	81%
P5	65%	71%	58%	73%
Main Test				
M1	63%	68%	58%	30%
M2	66%	67%	65%	36%
M3	56%	59%	53%	22%
M4	73%	71%	75%	57%
M5	10%	11%	10%	16%
M6	67%	68%	65%	23%
M7	76%	81%	71%	64%
M8	86%	84%	89%	73%
M9	71%	69%	74%	54%
M10	70%	69%	71%	41%
M11	76%	71%	81%	41%
M12	73%	71%	81%	41%
M13	68%	67%	69%	42%
M14	68%	67%	69%	31%
Avg. Time (min.)	14.18	13.28	15.12	16.93

B.7. Histogram and Normal Distribution of Data.

One of the assumptions made when analyzing the data was that it follows a normal distribution population. The normal population is modeled by the Gaussian curve given by:

EMBED Equation.3 (B.7.1)

where X is the average value of the data, and is the standard deviation.

Figure B.7.1 compares a histogram of the distribution of the total number of correct responses for all subjects to the Gaussian ideal. Obviously the distributions do not match well, but this can be partially attributed to the low scores from the Sound group as well as the small number of questions. In addition, the fit depends greatly on how the scores are grouped. Figure B.7.1 displays the data when grouped by the number of correct answers.

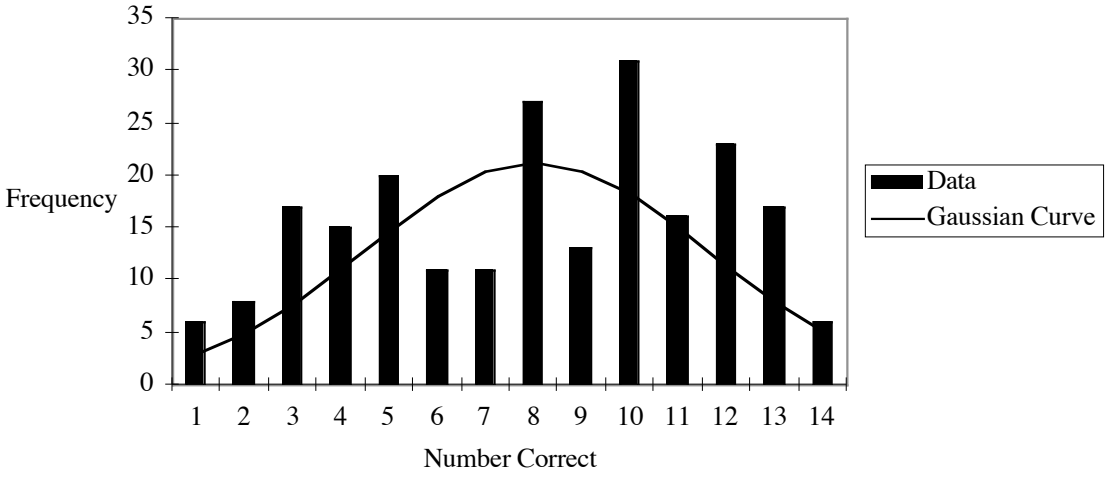


Figure B.7.1. Histogram of Web Pilot Data for All Subjects

A method for comparison of data distributions to the ideal Gaussian distribution is with a Normal Probability plot. In this graph the data is ordered from smallest to largest and then plotted with the points' value for the *y* axis, and the probability that an

observation from a normal distribution is smaller than the data point for the x axis value. [Sne89 p. 59] Ideally, the data points should lie on a line with a slope of $1/\sqrt{n}$. Sometimes the values are plotted as the standard normal deviate, in which case the x axis has units of the standard deviation and the slope is $\square$.

Figure B.7.2 shows that the distribution deviates from the normal. The fact that the distribution does not completely follow that of the normal may introduce some inaccuracies in the comparative tests as the F_{critical} and t_{critical} values assume normal distributions.

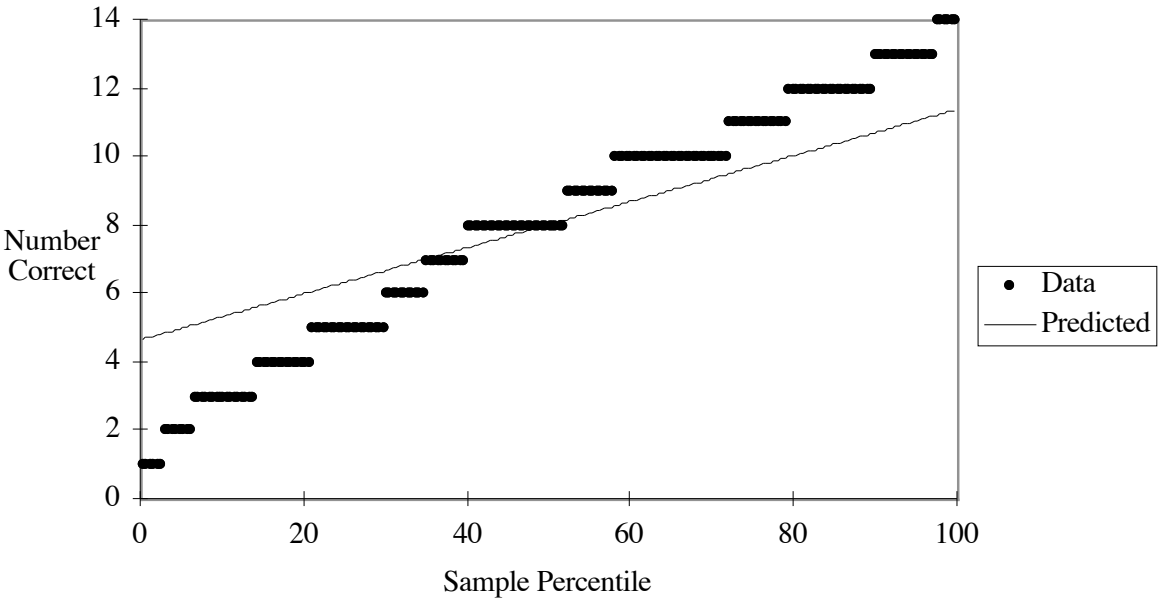


Figure B.7.2. Normal Probability Plot for All Subjects

Appendix C Material Relating to the Main Auditory Graph Test

C.1. Overview

This appendix contains material used in the Main Auditory Graph test. These materials include the Introductory page and Informed Consent form, the Introduction to Auditory Graphs Page, a sample page from the Main test and the questions and graphs used in the test. Following the test questions, there is a summary of the results obtained from the Main Auditory Graph test. Finally, there is a brief analysis of the distribution of test scores.

C.2. Introductory page and Informed Consent Form

Welcome

The object of this test is to compare students' ability to answer questions from data contained in graphical formats. Two types of graphs are utilized, pictorial graphs which almost everyone is familiar with, and sonified data graphs (data represented by sound), which is much less common. For the pictorial graphs, you will need a web browser such as Netscape or Explorer which can display .gif images. An example of such an image is the following:

The sonified data will be available in several sound formats: QuickTime, MIDI, and .wav files. The QuickTime .mov files are embedded in the pages and appear as a gray bar with controls. After these bars are links to midi and .wav files for downloading. QuickTime is the recommended format as it will be displayed on each page and is most convenient to use. The midi files are small (2 Kb) while the equivalent .wav files are large (about 130 Kb) and take a longer time to load. To hear the sound graphs you will need a multi-media computer capable of generating the sounds, such as a PC with a sound card, or a Mac; and the appropriate software. To listen to the QuickTime files, you will need Apple's QuickTime plug-in for your web browser. The following is a sample sound graph. Please make sure you can hear this graph before taking the test.

 MIDI WAV

If you do not see a bar above this line, and if QuickTime is installed, there may have a conflict with is your browser, if this is the case try reloading the page. If you do see the control bar, click on the "play" arrow to listen to the graph. The slider bar gives an indication of how much time has elapsed, you can move the slider to any point in the graph and play from that point.

To listen to the graph as a midi file, click on the MIDI link above; your browser should be configured to automatically start a midi player to listen to the file. You can also download the file by shift-clicking on the link. To listen to the graph as a .wav file, click on the WAV link above; again, your browser should be configured to automatically start a sound player after the file has downloaded. If you can hear the QuickTime graph then you do not need to use these links.

The Y axis of the sound graph is represented by pitch and the X axis is represented by time. The second derivative, or the rate at which the graph is increasing or decreasing is represented by the background

"clicks." Play the graph now to be sure your computer is configured correctly for these sounds. In the following pages, there will be detailed explanations and basic examples on how to listen to these graphs.

Before proceeding, please take a moment to read the following document.

Statement of Informed Consent

Physics Department, Oregon State University

Title of Project: Comparison Between Auditory and Visual Graphing Methods.

Investigators:
Steven Sahyun, Graduate Research Assistant, Physics Department.
John Gardner, Professor, Physics Department.

This purpose of this study, as stated above, is to determine whether auditory graphing (data representation using sound) is comparable to visually displayed graphs. In particular, this study will be examining how well conclusions can be drawn from auditory graphs vs. visually displayed graphs.

How the test will work:

The format for this test is divided into several parts. First, an introduction to auditory graphs is given, with samples and questions about these graphs. This is to provide a common basis of understanding.

Subjects will then be asked to give their name and a school code which is used to identify which testing group the student is from.

Next, a demographic survey will be presented to the subject for completion. This is to receive some indication of the subject's background and training. A Pre-test follows the survey and consists of five questions about two different graphs.

Finally, subjects are given a series of 17 graph questions relating to mathematics, and 17 questions relating to physics graphs. The questions are to be answered from the information contained within the graphs, although the subject matter is drawn from material that students are exposed to during a first year general physics course at a typical college or university.

Subjects will be randomly assigned to one of three groups. Those using picture graphs, those using sound graphs, and those using both sound and picture graphs (please listen to the graphs before answering the questions!)

Only data from subjects who answer all 34 test questions will be used.

It should be noted that all responses are being transferred on the Internet, and are not encrypted. However, reasonable attempts at confidentiality are made in that the subject's name will not appear with, or be stored with, any of their responses. Names will not be used in any publications or presentations of the data obtained.

It should also be noted that in cases where student subjects are taking this test for extra credit in a course, a list of which students have taken the test will be forwarded to the respective school's instructor so that those subjects may receive credit. Results of the study will not be used to determine credit, only the fact that the test has been taken. Also, a summary listing of the average responses to the test questions will be available to the instructor.

The test is estimated to take about 30 - 40 minutes.

Participation in this study is voluntary and you may either refuse to participate or withdraw from the study at any time, although full participation is greatly appreciated. You may take a break at any time, just be sure not to loose the web page question that you are on. If there should be a technical problem (crash) during the test, you will need to start over.

If you have any questions about the research study and/or specific procedures, please contact:
Steven Sahyun
Physics Department
Oregon State University
301 Weniger Hall
Corvallis OR, 97330
USA

The phone number is (541) 737-1712. Any other questions should be directed to Mary Nunn, Sponsored Programs Officer, OSU Research Office, Oregon State University, Corvallis, OR, 97331. The phone number is: (541) 737-0670.

After reviewing the above statement, please click on the link below:

I agree to this test.

Questions about this test? Send me e-mail:
sahyuns@ucs.orst.edu

Last modified April 28, 1998.

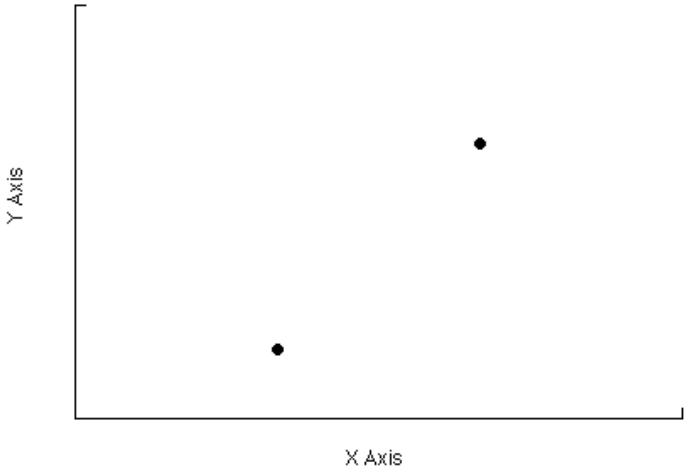
C.3. Introduction to Auditory Graphs

Before taking the test, subjects were given a web page introducing auditory graphs. This web page served as a training method for the auditory graphs. To provide equivalency between groups, all subjects were presented with this page.

Introduction to Auditory Graphs

Before the test begins, a short explanation about Auditory graphs is necessary for those who will be listening to the graphs instead of seeing them. **It is a random process as to who gets which graph type**, so everyone should understand how to listen to these graphs.

The basic auditory graph involves mapping the Y axis data to pitch, and the X axis data to time. So the greater the Y value, the higher the frequency of the sound, and the greater the X value the later the sound will be played. As an example, in the following graph there are two (X,Y) data points: (1,1) and (2,4). The (1,1) point can be heard first, and has a low tone, the (2,4) point is played second and has a higher tone.



MIDI WAV

Please play this graph now.

Note: The concept of 0 is difficult to represent in an auditory graph. We have used the following tone to represent 0 in all of the graphs in this test:

MIDI WAV

For most of the graphs that you will encounter, the lowest tone played will represent 0.

A series of points would be played as a series of tones. The following graph gives an example of a series of points that increase in both X and Y values:

MIDI WAV

Please play this graph now.

In previous studies, it was noticed that it is difficult to tell when a graph is linearly

increasing (i.e. Y = X), vs. when there is some curvature to the graph (i.e. $Y = X^2$). For this reason, a sound to alert the listener to the slope and curvature of a graph has been added. This sound is heard as a series of "drum" beats.

The slope of a graph is defined as the rise/run or $\frac{dY}{dX}$. The greater the slope, the more rapid the beat.

Please listen to the following graphs to determine which one has the greatest slope.

1: MIDI WAV

2: MIDI WAV

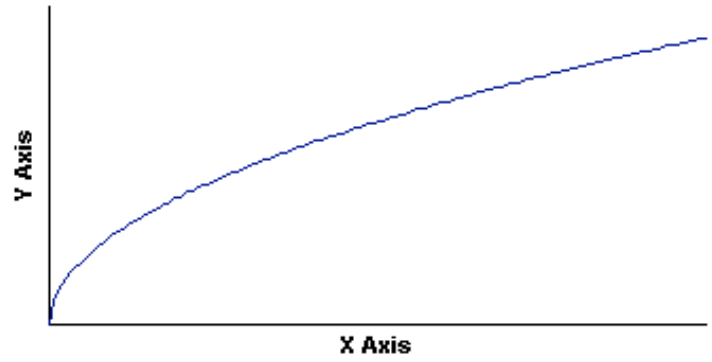
(The second graph has a greater slope)

The pitch of the drum beat indicates the curvature of the graph. The curvature is defined as the change in the slope, or $\frac{d^2Y}{dX^2}$. When the curvature is positive ($\frac{d^2Y}{dX^2} > 0$), as it is for the graph of $Y = X^2$, the graph is bowl shaped, and is represented with a low pitched drum beat. This graph looks and sounds like the following:

MIDI WAV

Please play this graph now.

When the curvature is negative ($\frac{d^2Y}{dX^2} < 0$) as in $Y = \sqrt{X}$, the graph is hat, or hill shaped. This type of graph has a high pitched drum beat. This graph looks and sounds like the following:



 MIDI WAV

Please play this graph now.

When there is no curvature ($\frac{d^2Y}{dX^2} = 0$), as was seen in the linear graphs above, (remember, the graph can still have a non-zero slope) the pitch of the drum beat is between those of the positive or negative curvature graphs.

If you would like to see and hear more examples, please go to the **Sonitype page**.

If this method of auditory graphing is clear, you're ready to

Start the Test

C.4. Pre-test and Survey

The Pre-test and Survey questions and layout were identical to those used in the Web Pilot test. For descriptions and screen images, see Appendix B, sections 3 and 4.

C.5. Main Auditory Graph Test

The question layout for the Main test questions was similar to the layout for the Web Pilot test, although an extra sound bar was included for use as a reference to 0. Figure C.5.1 is a screen image of a typical question page presented to the subjects. The questions of the test and their related graphs follow the figure.

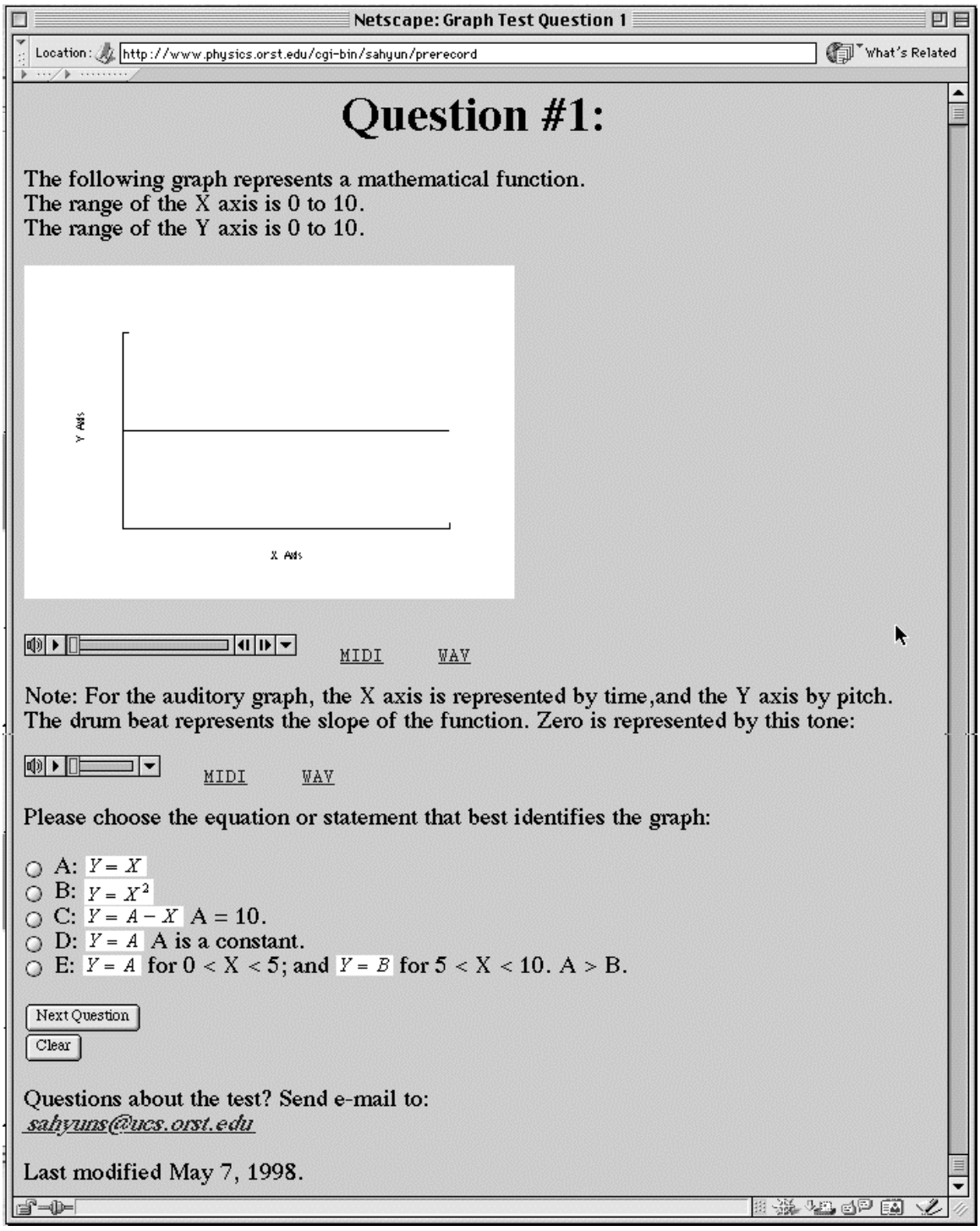


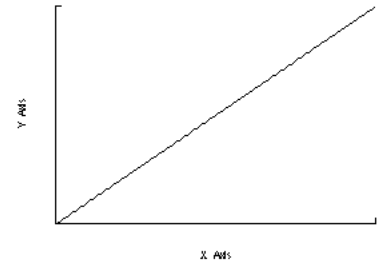
Figure C.5.1. Question Layout for Main Auditory Graph Test

Question 1:

The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 10.

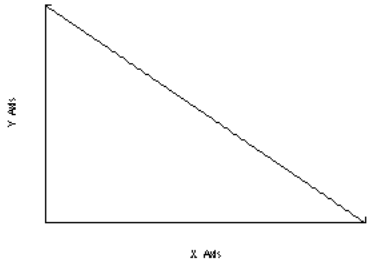
Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = A \square X$ A = 10.
D: $Y = A$ A is a constant.
E: $Y = A$ for 0 < X < 5; and $Y = B$ for 5 < X < 10. A > B.
Answer is: D

Question 2:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 10.



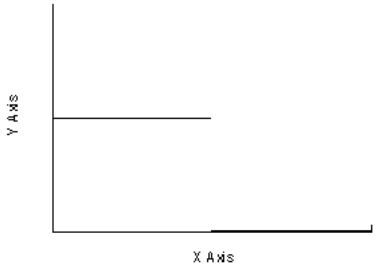
Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = A \square X$ A = 10.
D: $Y = A$ A is a constant.
E: $Y = A$ for 0 < X < 5; and $Y = B$ for 5 < X < 10. A > B.
Answer is: A

Question 3:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 10.



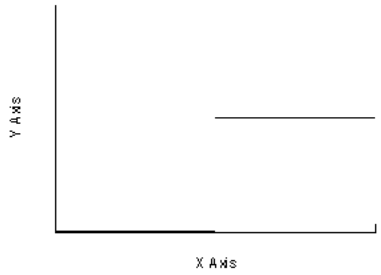
Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = A \square X$ A = 10.
D: $Y = A$ A is a constant.
E: $Y = A$ for 0 < X < 5; and $Y = B$ for 5 < X < 10. A > B.
Answer is: C

Question 4:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 10.



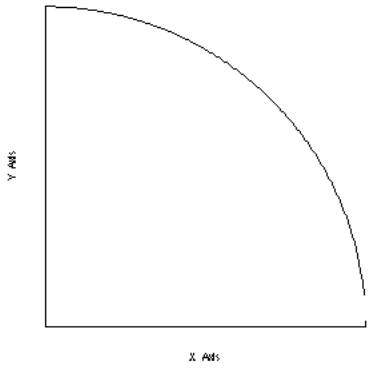
Please choose the equation or statement that best identifies the graph:
A: Y = X.
B: Y = A. A is a constant.
C: Y = A - X. A = 10.
D: Y = A for 0 < X < 5; and Y = B for 5 < X < 10. A > B.
E: Y = A for 0 < X < 5; and Y = B for 5 < X < 10. A < B.
Answer is: D

Question 5:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 10.



Please choose the equation or statement that best identifies the graph:
A: Y = X.
B: Y = A. A is a constant.
C: Y = A - X. A = 10.
D: Y = A for 0 < X < 5; and Y = B for 5 < X < 10. A > B.
E: Y = A for 0 < X < 5; and Y = B for 5 < X < 10. A < B.
Answer is: E

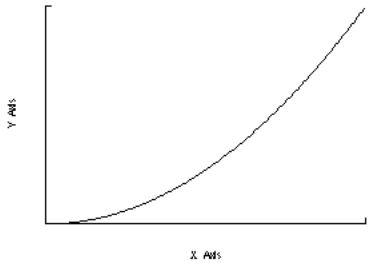
Question 6:
The following graph represents a mathematical function.
The range of the X axis is 0 to 1.
The range of the Y axis is 0 to 1.



Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = \square X^2$
D: $Y = \sqrt{1 \square X^2}$
E: $Y = \sqrt{X}$
Answer is: D

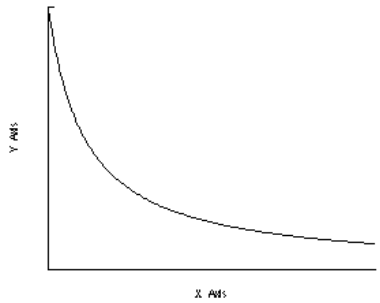
Question 7:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.

The range of the Y axis is 0 to 100.



Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = \square X^2$
D: $Y = \sqrt{1 \square X^2}$
E: $Y = \sqrt{X}$
Answer is: B

Question 8:
The following graph represents a mathematical function.
The range of the X axis is 1 to 10.
The range of the Y axis is 0 to 1.

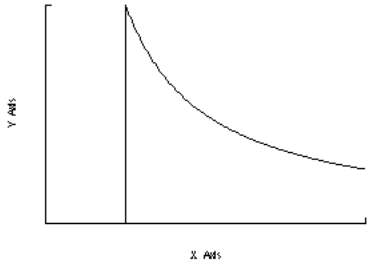


Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = 1/X$
D: $Y = \sqrt{1 \square X^2}$
E: $Y = \sqrt{X}$
Answer is: C

Question 9:
The following graph represents a mathematical function.
The range of the X axis is 0 to 4.
The range of the Y axis is 0 to 1.

Please choose the equation or statement that best identifies the graph:
A: Y = X.
B: Y = 0 for 0 < X < 1; and Y = X for 1 < X < 4.
C: Y = X for 0 < X < 1; and Y = 1 - X for 1 < X < 4.
D: Y = 0 for 0 < X < 1; and Y = 1/X for 1 < X < 4.
E: Y = X for 0 < X < 1; and Y = 1/X for 1 < X < 4.
Answer is: E

Question 10:
The following graph represents a mathematical function.
The range of the X axis is 0 to 4.
The range of the Y axis is 0 to 1.

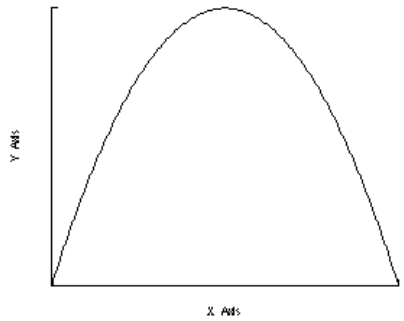


Please choose the equation or statement that best identifies the graph:
A: Y = X.
B: Y = 0 for 0 < X < 1; and Y = X for 1 < X < 4.
C: Y = X for 0 < X < 1; and Y = 1 - X for 1 < X < 4.
D: Y = 0 for 0 < X < 1; and Y = 1/X for 1 < X < 4.
E: Y = X for 0 < X < 1; and Y = 1/X for 1 < X < 4.
Answer is: D

Question 11:
The following graph represents a mathematical function.
The range of the X axis is 0 to 100.
The range of the Y axis is 0 to 10.

Please choose the equation or statement that best identifies the graph:
A: $Y = X$
B: $Y = X^2$
C: $Y = 1/X$
D: $Y = \sqrt{1 - X^2}$
E: $Y = \sqrt{X}$
Answer is: E

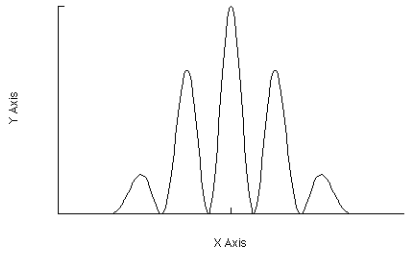
Question 12:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 125.



Please choose the equation or statement that best identifies the graph:
A: $Y = AX - \frac{1}{2}BX^2$
B: $Y = e^{-(5-X)^2}$
C: $Y = \sin^2(X)$
D: $Y = \sqrt{1 - X^2}$
E: $Y = X + \sin(X)$
Answer is: A

Question 13:

The following graph represents a function with one or more maxima.



Which statement best describes this graph?
A: This graph contains 5 peaks of equal magnitudes.
B: This graph contains 5 peaks of unequal magnitudes.
C: This graph contains 5 peaks of random magnitudes.
D: This graph contains 10 peaks of random magnitudes.
E: This graph contains only 1 peak.
Answer is: B

Question 14:
The following graph represents a mathematical function.
The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 1.

Please choose the equation or statement that best identifies the graph:

A: $Y = AX - \frac{1}{2}BX^2$

B: $Y = e^{-(5-X)^2}$

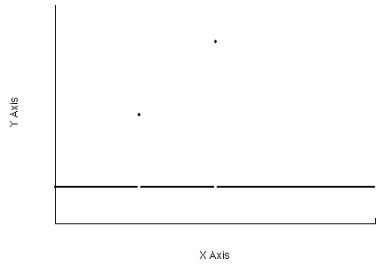
C: $Y = \sin^2(X)$

D: $Y = \sqrt{1 - X^2}$

E: $Y = X + \sin(X)$

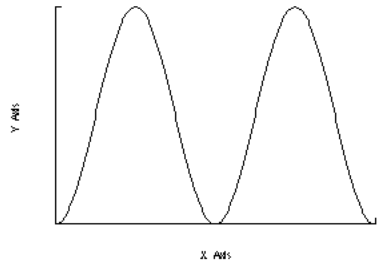
Answer is: B

Question 15:
The following graph represents a function with one or more discontinuities.



Which statement best describes this graph?
A: This graph contains 2 points of discontinuity whose function values are of unequal magnitudes.
B: This graph contains 2 points of discontinuity whose function values are of equal magnitudes.
C: This graph contains 2 points of discontinuity at which the function is undefined.
D: This graph contains 4 points of discontinuity whose function values are of unequal magnitudes.
E: This graph contains 4 points of discontinuity whose function values are of equal magnitudes.
Answer is: A

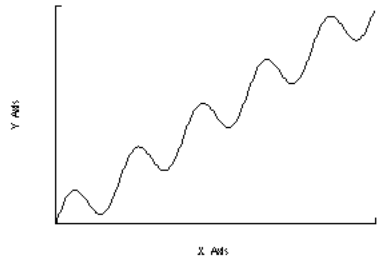
Question 16:
The following graph represents a mathematical function.
The range of the X axis is 0 to 2 Pi (= 6.3).
The range of the Y axis is 0 to 1.



Please choose the equation or statement that best identifies the graph:
A: $Y = AX - \frac{1}{2}BX^2$
B: $Y = e^{-(5-X)^2}$
C: $Y = \sin^2(X)$
D: $Y = \sqrt{1 - X^2}$
E: $Y = X + \sin(X)$
Answer is: C

Question 17:
The following graph represents a mathematical function.

The range of the X axis is 0 to 10.
The range of the Y axis is 0 to 10.



Please choose the equation or statement that best identifies the graph:

A: $Y = AX - \frac{1}{2}BX^2$

B: $Y = e^{-(5-X)^2}$

C: $Y = \sin^2(X)$

D: $Y = \sqrt{1 - X^2}$

E: $Y = X + \sin(X)$

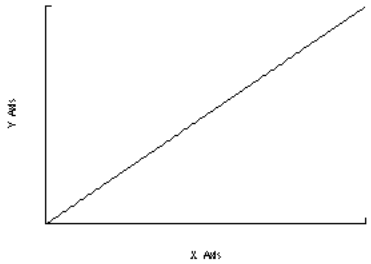
Answer is: E

Question 18:
This is a graph of the motion of an object.
The X axis represents time, and has a range of 0 to 10 seconds.
The Y axis represents the object's distance from a reference point, and has a range of 0 to10 m.

Choose the sentence that is the best interpretation of the graph:
A: The object is moving with a constant non-zero linear acceleration.
B: The object does not move.
C: The object is moving with an acceleration whose magnitude is decreasing.
D: The object is moving with a constant non-zero linear velocity.
E: The object is moving with an acceleration whose magnitude is increasing.
Answer is: B

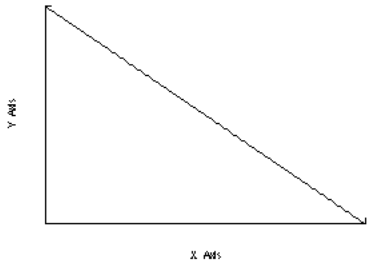
Question 19:
This is a graph of the motion of an object.
The X axis represents time, and has a range of 0 to 10 seconds.

The Y axis represents the object's velocity, and has a range of 0 to 10 m/s.



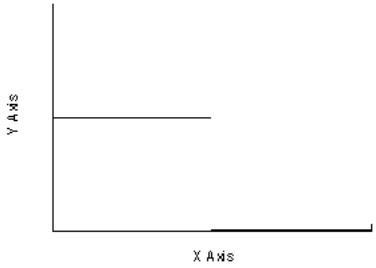
Choose the sentence that is the best interpretation of the graph:
A: The object is moving with a constant, non-zero acceleration.
B: The object is moving with an acceleration whose magnitude is decreasing.
C: The object is moving with an acceleration whose magnitude is increasing.
D: The object is moving with a constant velocity.
E: The object is moving with a decreasing velocity.
Answer is: A

Question 20:
This is a graph of the motion of an object.
The X axis represents time, and has a range of 0 to 10 seconds.
The Y axis represents the object's velocity, and has a range of 0 to 10 m/s.



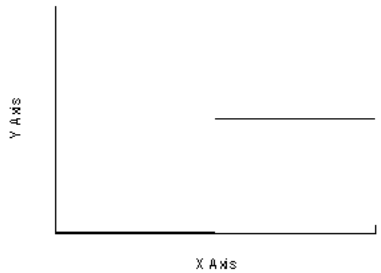
Choose the sentence that is the best interpretation of the graph:
A: The object is moving with a constant, non-zero acceleration.
B: The object is moving with an acceleration whose magnitude is decreasing.
C: The object is moving with an acceleration whose magnitude is increasing.
D: The object is moving with a constant velocity.
E: The object is moving with an increasing velocity.
Answer is: A

Question 21:
A force is applied to a 1 Kg object according to the graph below. The object moves without friction.
The X axis represents time; the range of the X axis is 0 to 2 seconds.
The Y axis represents the applied force; the range of the Y axis is 0 to 2 Newtons.



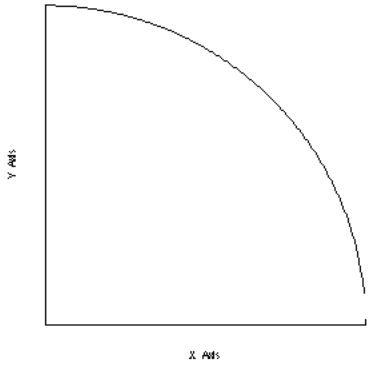
Choose the best completion to the following statement:
At 2 seconds, the object
A: is moving with an increasing velocity.
B: is moving with a constant velocity.
C: is moving with a decreasing velocity.
D: is not moving.
E: is moving backwards.
Answer is: B

Question 22:
The following graph represents the current in a simple circuit consisting of a wire connecting a battery, a switch, and a resistor.
The X axis represents time; the range of the X axis is 0 to 2 seconds.
The Y axis represents the current in the wire; the range of the Y axis is 0 to 2 Amps.



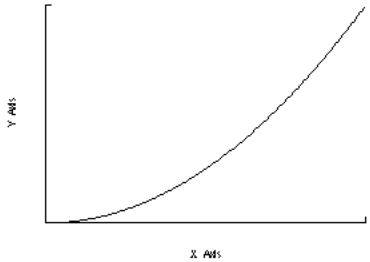
Choose the best statement about the graph:
This graph shows
A: the current steadily increasing from 0 to 2 Amps.
B: the current steadily decreasing from 2 to 0 Amps.
C: that the current suddenly changes from 0 to 2 Amps.
D: that the current suddenly changes from 2 to 0 Amps.
E: that the current does not change.
Answer is: C

Question 23:
The following graph represents the position trajectory of an object traveling with constant speed. The object is moving from a minimum X value to a maximum X value.
The range of the X axis is 0 to 1 meter.
The range of the Y axis is 0 to 1 meter.



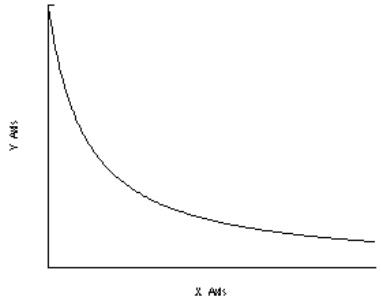
Which statement best describes the acceleration of the object?
A: The acceleration of the object is 0.
B: The acceleration of the object is parallel to the direction of travel.
C: The acceleration of the object is perpendicular to the direction of travel.
Answer is: C

Question 24:
The following graph is for the elastic potential energy of a material.
The X axis represents the distance that the spring is compressed.
The Y axis represents the potential energy of the spring.



Choose the sentence that is the best interpretation of the graph:
A: The elastic potential energy increases as the square of the distance that the material is compressed.
B: The elastic potential energy is increasing linearly with the distance the material is compressed.
C: The elastic potential energy is a non-zero constant as the material is compressed.
D: The elastic potential energy is decreasing.
E: The elastic potential energy of the material is 0.
Answer is: A

Question 25:
The following graph represents an ideal gas in a container.
The X axis represents volume and has a range of 1 to 10 L^3.
The Y axis represents pressure and has a range of 0 to 1 Atm.



Please choose the statement that best describes the relationship between pressure and volume:
A: The pressure is constant as the volume changes.
B: The pressure is not related to the volume.
C: The pressure increases linearly as the volume increases.
D: The pressure decreases linearly as the volume increases.
E: The pressure decreases as 1/volume.
Answer is: E

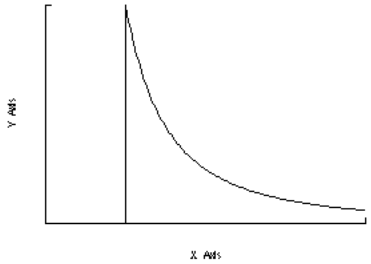
Question 26:
The following graph refers to the gravitational force produced by a sphere of mass M, acting on a test object of mass m.
The X axis represents distance, and has a range of 0 to 4 R (R = radius of sphere.)
The Y axis represents the gravitational force, and has a range of 0 to 1 $\frac{GMm}{R^2}$.

Choose the sentence that is the best interpretation of the graph.
A: The gravitational force first increases as $(\text{distance})^2$ until distance = R, then decreases linearly.
B: The gravitational force first increases as $(\text{distance})^2$ until distance = R, then is proportional to $\frac{1}{(\text{distance})^2}$.
C: The gravitational force first increases linearly until distance = R, then decreases linearly.
D: The gravitational force first increases linearly until distance = R, then is proportional to $\frac{1}{(\text{distance})^2}$.

E: The gravitational force is not related to the distance.
Answer is: D

Question 27:
The following graph refers to the electric field produced by a charged sphere.
The X axis represents distance, and has a range of 0 to 4 R (R = radius of the spherical shell.)

The Y axis represents the electric field, and has a range of 0 to 1 $\frac{Q}{4\pi R^2 \varepsilon_0}$.

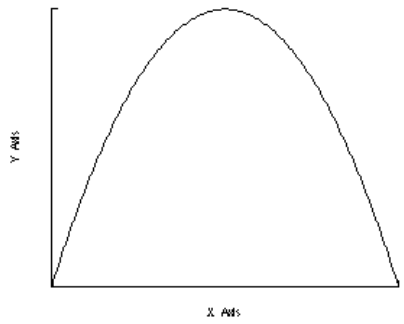


Choose the sentence that is the best interpretation of the graph.
A: The electric field is 0 until distance = R, then decreases linearly from a maximum value.
B: The electric field is 0 until distance = R, then is proportional to $\frac{1}{(\text{distance})^2}$.
C: The electric field increases linearly until distance = R, then decreases linearly.
D: The electric field increases linearly until distance = R, then is proportional to $\frac{1}{(\text{distance})^2}$.
E: The electric field is not related to the distance.
Answer is: B

Question 28:
When the ocean depth is greater than three wavelengths, the speed of waves in the ocean is approximated by the following graph.
The X axis represents the wavelength, and has a range of 0 to 1000 m.
The Y axis represents the velocity of ocean waves, and has a range of 0 to 40 m/s.

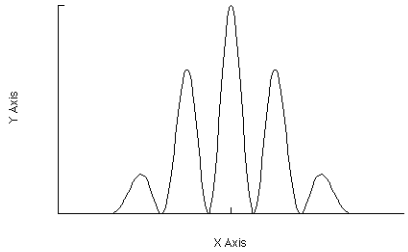
Choose the sentence that is the best interpretation of the graph.
A: The speed of ocean waves is proportional to the wavelength.
B: The speed of ocean waves decreases with increasing wavelength.
C: The speed of ocean waves is proportional to the square root of the wavelength.
D: The speed of ocean waves is proportional to $(\text{wavelength})^2$.
E: The speed is not dependent on the wavelength.
Answer is: C

Question 29:
The following graph shows the trajectory of a projectile with a constant velocity component in the X direction.
The X axis represents distance, and has a range of 0 to 10 m.
The Y axis represents height, and has a range of 0 to 125 m.



Choose the sentence that is the best interpretation of the graph.
A: At the graph's maximum Y value, the magnitude of the projectile's velocity component in the Y direction is 0.
B: At the graph's maximum Y value, the magnitude of the projectile's velocity component in the Y direction is greater than 0.
C: Just before the graph's maximum X value, the magnitude of the projectile's velocity component in the Y direction is 0.
D: At the graph's maximum Y value, the projectile's acceleration is 0.
E: At the graph's maximum Y value, the projectile's distance is 0.
Answer is: A

Question 30:
The following graph shows the pattern of light intensity projected onto a screen from a monochromatic light source.
The X axis represents distance on the screen, and has a range of -1 to 1 mm.
The Y axis represents relative light intensity, and has a range of 0 to 1.



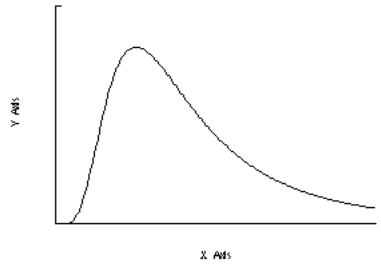
This pattern represents light that:
A: has passed through a single slit aperture.
B: has passed through a double slit aperture.
C: has passed through a diffraction grating.
D: is produced by a light beam with a single central maximum intensity.
E: displays the effects of edge diffraction from a semi-infinite screen.
Answer is: B

Question 31:
The following graph shows the pattern of light intensity projected onto a screen from a monochromatic light source.
The X axis represents distance on the screen, and has a range of -1 to 1 mm.
The Y axis represents relative light intensity, and has a range of 0 to 1.

This pattern represents light that:
A: has passed through a single slit aperture.
B: has passed through a double slit aperture.
C: has passed through a diffraction grating.
D: is produced by a light beam with a single central maximum intensity.
E: displays the effects of edge diffraction from a semi-infinite screen.
Answer is: D

Question 32:
The following graph shows the light intensity produced by a black body object, such as the Sun, with a temperature at 5000 K.

The X axis represents the wavelength of light, and has a range of 0 to 2000 nm.
The Y axis represents relative light intensity, and has a range of 0 to 1.

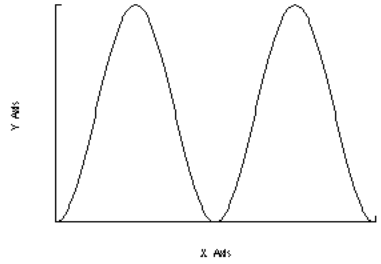


Please choose the sentence that best describes the graph.
A: There is a constant distribution of light intensity vs. wavelength
B: The maximum intensity occurs at approximately 500 nm.
C: The maximum intensity occurs at approximately 1000 nm.
D: The maximum intensity occurs at approximately 1500 nm.
E: The intensity is increasing throughout this range.
Answer is: B

Question 33:
In an AC (alternating current) circuit, the instantaneous electric power dissipated by a resistor is given in the following graph.

The X axis represents time, and has a range of 0 to $\frac{2\pi}{\omega}$ Seconds. Where w is the frequency of the AC.

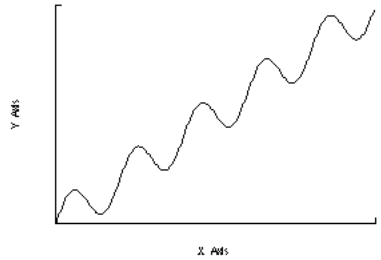
The Y axis represents power dissipated, and has a range of 0 to 1 $\frac{\mathcal{E}_{max}^{2}}{R}$. E_{max} is the maximum EMF Voltage amplitude.



Please choose the sentence that best describes the graph.
A: The instantaneous power dissipated is a non-zero constant in time.
B: The instantaneous power dissipated is always decreasing with time.
C: The instantaneous power dissipated is always increasing with time.
D: The instantaneous power dissipated is 0 at specific points in time.
E: The instantaneous power dissipated is always 0.
Answer is: D

Question 34:

A test mass is suspended by springs on a cart. Assume that the mass of the cart is much greater than that of the test mass. The following graph describes the motion of the test mass in the Y direction.
The X axis represents time, and has a range of 0 to 10 Seconds.
The Y axis represents distance that the mass has traveled, and has a range of 0 to 1 m.



Please choose the sentence that best describes the conditions to produce the motion portrayed in the graph. All velocities are in the lab rest frame.
A: Only the cart was given an initial velocity in the Y direction.
B: Only the test mass was given an initial velocity in the Y direction.
C: The cart was given an initial velocity in the Y direction while the test mass was given an initial velocity in the - Y direction.
D: The cart and test mass are given the same initial velocity in the Y direction.
E: The test mass is given twice the initial velocity of the cart in the Y direction.
Answer is: E

C.6. Summary Table of Results from the Main Test

Table C.6.1 and Table C.6.2 are summaries of the results obtained from the Main Auditory Graph test. The tables are divided into six columns: All, Vision, Both, Sound, Blind, and Grad. The All category represents the average of the scores from the Vision, Both, and Sound groups. Vision represents the subjects given the test with visually presented graphs, Both represents the group given the test with both visual and auditory graphs, and Sound represents the subjects given the test with only auditory graphs. The Blind group had subjects who were blind and took the test. Only one of these five subjects answered the Pre-test questions. The Grad group represents 6 physics graduate students who took the test with only auditory graphs.

Table C.6.1 Summary of results for the Main Auditory Graph Test. Part I.

Group	All (B, S, V)	Visual	Both	Sound	Grad	Blind
# Subjects	231	76	81	74	6	5
% Female	48%	41%	59%	43%	17%	20%
Avg Age	22	22	22	22	29	38
% Correct Answers:						
Pre-Test						
pt1	78%	72%	83%	78%	100%	20%*
pt2	96%	95%	96%	97%	83%	20%*
pt3	92%	93%	89%	93%	83%	20%*
pt4	79%	67%	81%	89%	100%	20%*
pt5	63%	55%	68%	66%	100%	20%*
Main Test						
mt1	68%	84%	64%	57%	100%	100%
mt2	71%	86%	79%	46%	83%	100%
mt3	80%	82%	80%	77%	100%	100%
mt4	77%	78%	79%	76%	100%	100%
mt5	77%	80%	83%	69%	100%	100%
mt6	42%	61%	42%	24%	67%	80%
mt7	78%	83%	81%	70%	100%	100%
mt8	74%	76%	78%	68%	100%	80%
mt9	60%	66%	68%	45%	100%	60%
mt10	65%	62%	75%	55%	83%	80%
mt11	51%	58%	58%	36%	100%	80%
mt12	30%	38%	38%	14%	67%	40%
mt13	61%	68%	65%	49%	83%	80%
mt14	22%	28%	17%	22%	83%	40%
mt15	63%	66%	63%	59%	83%	80%
mt16	47%	49%	46%	46%	100%	80%
mt17	28%	30%	26%	28%	100%	80%
mt18	49%	57%	51%	41%	83%	100%
mt19	37%	42%	35%	35%	33%	60%
mt20	23%	21%	28%	19%	83%	80%
mt21	36%	41%	41%	26%	83%	20%
mt22	81%	76%	81%	84%	100%	100%
mt23	55%	62%	44%	58%	50%	80%
mt24	71%	72%	79%	62%	100%	100%
mt25	60%	70%	62%	49%	100%	100%
mt26	52%	58%	62%	36%	100%	60%
mt27	59%	63%	64%	50%	100%	100%
mt28	47%	54%	58%	27%	100%	100%
mt29	44%	54%	43%	35%	83%	40%
mt30	49%	45%	48%	54%	17%	80%
mt31	38%	37%	36%	42%	83%	60%
mt32	68%	72%	70%	62%	100%	80%
mt33	69%	72%	70%	64%	100%	100%
mt34	19%	18%	16%	23%	17%	0%
Avg Time (min.)	29.37	23.56	30.72	33.86	39.74	2488.98

* = only 1 Blind subject answered the pre-test

Table C.6.2 Summary of results for the Main Auditory Graph Test. Part 2.

Avg. # Correct	All	Visual	Both	Sound	Grad	Blind
Pre-Test	4.08	3.83	4.17	4.24	4.67	1.00*
Std. Dev.	0.65	0.86	0.52	0.63	0.46	0.00*
Main Test	18.53	20.08	19.32	16.07	28.83	26.40
Std. Dev.	5.93	6.03	5.46	5.59	3.31	3.71
Math Section	9.95	10.93	10.43	8.41	15.50	13.80
Std. Dev.	3.40	3.39	2.98	3.35	1.76	1.92
Physics Section	8.58	9.14	8.89	7.66	13.33	12.60
Std. Dev.	3.18	3.41	3.15	2.78	1.75	2.07
r = Math/Physics correlation	0.31	0.27	0.44	0.17	0.31	0.27
Split Half Reliability	0.47	0.43	0.61	0.29	0.47	0.42
	Average	# Subjects				
Sound with Music Trianing	16.91	47				
Sound w/o Music Trianing	14.59	27				

* = only 1 Blind subject answered the pre-test

C.7. Histograms and Tests of Normal Distribution of Data

In Chapter 9, the data were assumed to follow a normal distribution so that *t*-tests could be applied. The following charts show that the data is a fair, but not perfect approximation to the ideal Normal population distribution. In this test, there seems to be a few more outlying data points than would normally be expected. Appendix B.7 has a discussion on the techniques used for the Normal Probability graphs.

Figure C.7.1 portrays a histogram of the distribution of scores on the Main test. The distribution closely, but not perfectly follows the Gaussian ideal. These results are greatly improved over those of the Web Pilot Test. 0 displays the Normal Probability plot of the distribution. As can be readily seen, the slope of the best fit (0.20) is not in perfect agreement with the $1/\sqrt{n} = 1/\sqrt{231} = 0.07$ slope of the predicted ideal. A normal population would have a 0.20 slope if the sample size were 25 rather than the 231 used in this study. Separating the subject groups showed similar results.

Thus, the data does not follow a perfect normal population distribution which may introduce some inconsistent results in the tests applied in Chapter 9. However, it should be noted that the data is not radically different from a normal population, so the general analysis should be satisfactory.

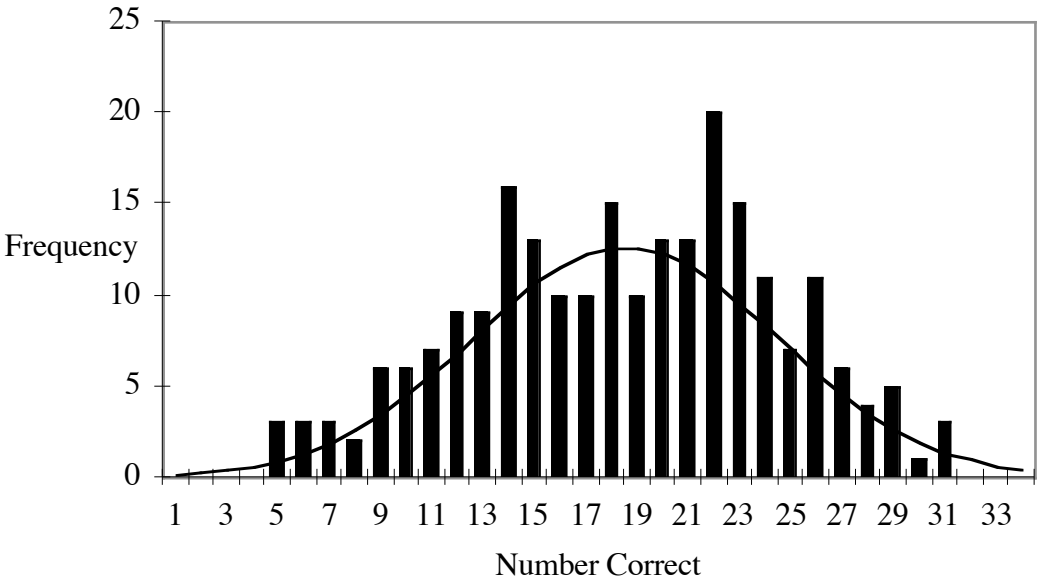


Figure C.7.1. Comparison of All subjects (S, B, and V groups) to the Gaussian Ideal.

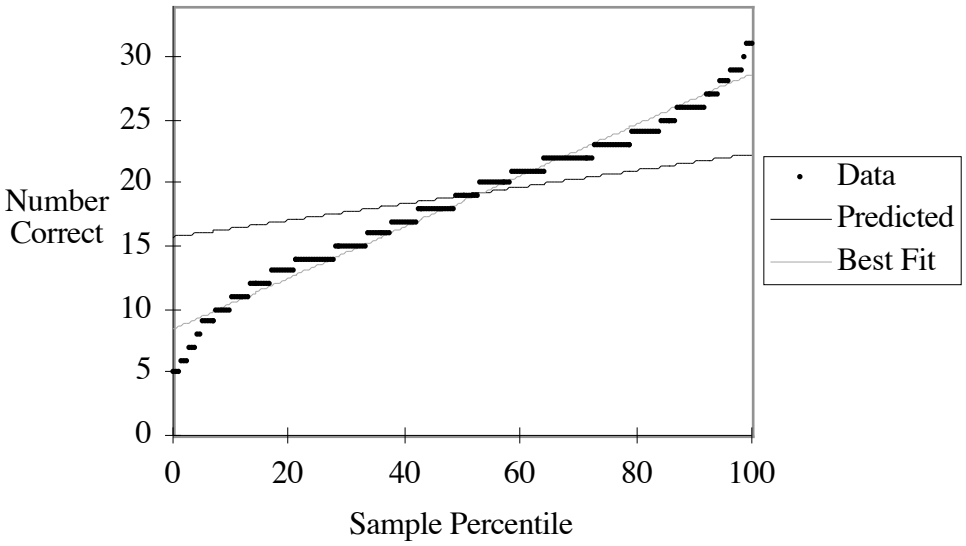


Figure C.7.2. Normal Probability distribution for All (S, V, and B groups).

Appendix D Material Relating to the Auditory Preference Pilot Test

D.1. Overview

This appendix contains material used in the Auditory Preference Pilot test. These materials include the Introductory page, Informed Consent form, and the question pages. There is also a summary of the results obtained from this test as well as a listing of the subject's text responses for each of the questions.

D.2. Introductory page and Informed Consent Form

Welcome

The object of this test is to compare preferences between different types of auditory representations of graphical information. Two types of graphs are utilized, pictorial graphs which almost everyone is familiar with, and sonified data graphs (data represented by sound), which is much less common.

In general, the Y axis of the pictured graph will be represented by pitch and the X axis by time. Additionally, some of the auditory graphs may contain characteristics relating to first and second derivative values as well as negative quantities.

As this is a test about preferences, many questions do not have a right or wrong answer, simply respond as to which choice seems to work best.

To listen to the graphs when they are presented, click on the button marked “Play” next to the answer choice. You can play a graph as many times as you like. Answers will be of a multiple-choice format, with a text area for additional comments.

Hardware and software requirements for this test are a sound capable computer, Windows95, and Internet Explorer 4.0 or greater. Some of the sounds used in this test utilize Microsoft’s ActiveX controls. Due to the nature of these controls, some pages may take a minute or two to load. Please be patient.

Since some of the ActiveX controls are not registered, the View -> Internet Options -> Security setting will need to be set to Low. Neither Oregon State University, nor the investigators assume any responsibility for the actions of these controls. **Use at your own risk.**

Before proceeding, please take a moment to read the following document.

Statement of Informed Consent

Physics Department, Oregon State University

Title of Project: Comparison Between Auditory and Visual Graphing Methods.

Investigators:
Steven Sahyun, Graduate Research Assistant, Physics Department.
John Gardner, Professor, Physics Department.

This purpose of this study, as stated above, is to determine preferences between auditory graphing (data representation using sound) methods.

How the test will work:

Subjects will be given a log-in page that records their name. Names are not stored the same computer file as responses.

Subjects will then be given a series of 9 pages containing questions in multiple-choice and Likert scale preference formats. Also, some questions will ask for identification of displayed graphs.

Only data from subjects who answer all 9 question pages will be used.

It should be noted that all responses are being transferred on the Internet, and are not encrypted. However, reasonable attempts at confidentiality are made in that the subject's name will not appear with, or be stored with, any of their responses. Names will not be used in any publications or presentations of the data obtained.

It should also be noted that in cases where student subjects are taking this test for extra credit in a course, a list of which students have taken the test will be forwarded to the respective school's instructor so that those subjects may receive credit. Results of the study will not be used to determine credit, only the fact that the test has been taken. Also, a summary listing of the average responses to the test questions will be available to the instructor.

The test is estimated to take about 10 minutes.

Participation in this study is voluntary and you may either refuse to participate or withdraw from the study at any time, although full participation is greatly appreciated. You may take a break at any time, just be sure not to loose the web page question that you are on. If there should be a technical problem (crash) during the test, you will need to start over.

If you have any questions about the research study and/or specific procedures, please contact:
Steven Sahyun
Physics Department
Oregon State University
301 Weniger Hall
Corvallis OR, 97330
USA
The phone number is (541) 737-1712. Any other questions should be directed to Mary Nunn, Sponsored Programs Officer, OSU Research Office, Oregon State University, Corvallis, OR, 97331. The phone number is: (541) 737-0670.

After reviewing the above statement, please click on the link below:

I agree to this test.

Questions about this test? Send me e-mail:
sahyuns@ucs.orst.edu

Last modified November 10, 1998.

D.3. Test Questions

The questions used in the Auditory Preference Pilot Test were displayed as a series of 9 Web pages. Each question displayed a series of choices with radio style button selectors, as well as a text entry field so that they could record comments relating to their choice selection. Figure D.3.1 demonstrates a typical question. The text of the different questions, as well as an explanation of which sound graphs were being compared follows the figure.

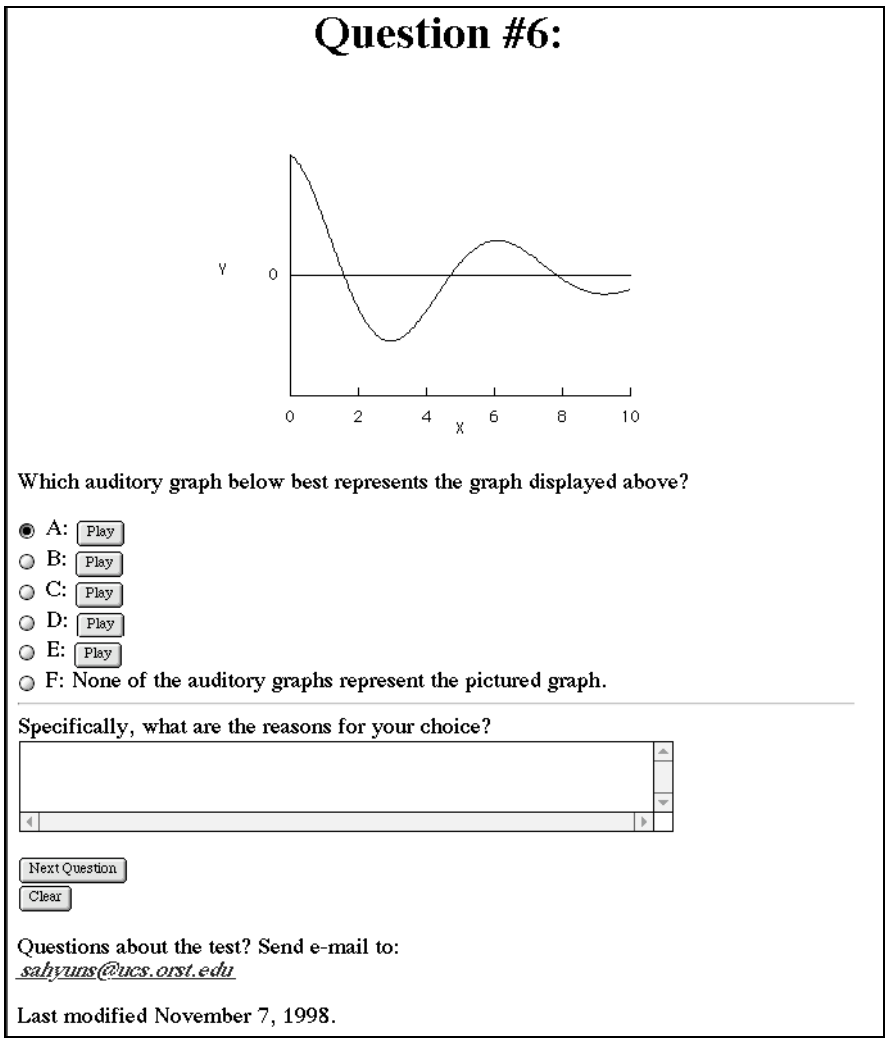
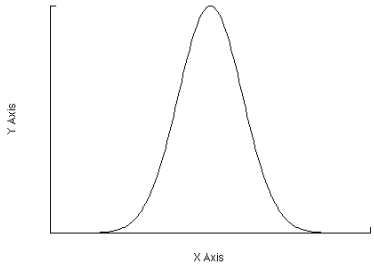


Figure D.3.1. Typical Question Layout for the Auditory Preference Pilot Test

Question #1:



Which of the auditory graphs below, if any, do you prefer as best matching the graph displayed above?

In these auditory graphs, the y axis is represented by pitch and the x axis with time.

A: Play
B: Play
C: Both represent the graph equally well.
D: Neither represents the graph well.

Specifically, what are the reasons for your choice?

Next Question
Clear

Comment on Question 1:

This question compared two Auditory representations of a Gaussian curve using only pitch to represent the curve. Choice A used an ActiveX control producing a smooth, continuously varying tone, while Choice B used the MIDI piano instrument with notes representing data points. This question was intended to check how many people preferred the smooth tone versus the more staccato sounding MIDI.

Question 2 used the same graph as in question 1, but the text read as:

In the auditory graphs below, the y axis is represented by the pitch of the piano tone, and the x axis is represented by time. Additionally, the first derivative (slope) is represented by the frequency of a drum beat. The second derivative (curvature) is represented by the pitch of the drum beat.

Which auditory graph do you prefer as best matching the graph displayed above?
A: Play
B: Play

C: Both represent the graph equally well.
D: Neither represents the graph well.

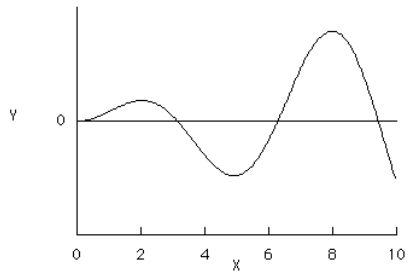
Specifically, what are the reasons for your choice?

Next Question
Clear

Comment on question 2:

This question compared two MIDI graphs, where the difference was the pitch of a tick mark (drum-beat) representing the first (slope) and second (curvature) derivatives. Choice A used the mapping of a low tone for the tick mark pitch when the curvature was positive, and a high tone when it was negative. Choice B used the reverse mapping in that the positive curvature had a high pitch tone and negative had a low pitch.

Question #3:



In the auditory graphs below, the y axis is represented as pitch and the x axis as time.

Which auditory graph do you prefer as best matching the graph displayed above?

A: Play
B: Play
C: Both represent the graph equally well.
D: Neither represents the graph well.

Specifically, what are the reasons for your choice?

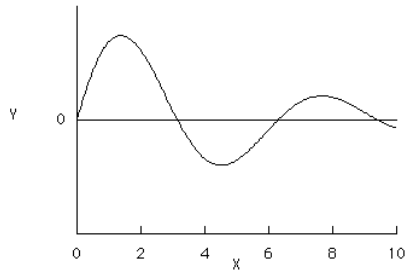
Next Question
Clear

Comment on Question 3:

This question used two MIDI auditory graphs to determine it there was a preference for indicating when the graph's y axis values were negative. Choice B had an instrument change from piano to harpsichord for negative values, while Choice A had no change.

Question 4 had the same graph and similar wording to question 3, but compared subjects' preference for the ActiveX smooth tone and tick mark beats having high pitch for positive values and low pitch for negative values (Choice A) to a MIDI graph with drum-beats (high pitch for negative values, low pitch for positive ones) and an instrument change for negative *y* axis values (Choice B). A change in the tone quality representing negative *y* axis values was not used with the ActiveX graph as this feature was not available at the time of testing.

Question #5:



Which auditory graph below best represents the graph displayed above?

A: Play
B: Play
C: Play
D: Play
E: Play
F: None of the choices represent the displayed picture.

Specifically, what are the reasons for your choice?

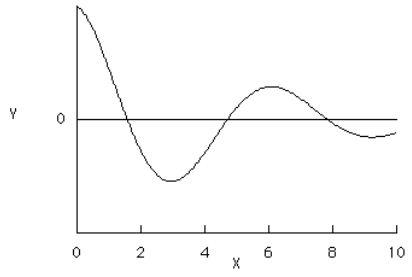
Next Question
Clear

Comments on question 5:

This question was intended to determine how effectively subjects could match a visually presented graph to an ActiveX graph with the tick mark beats having high pitch

for positive values and low pitch for negative values. The five graph choices were representations of (A) sin x, (B) cos x, (C) x sin x, (D) e^{-x} sin x , and (E) e^{-x} cos x.

Question #6:



Which auditory graph below best represents the graph displayed above?

A: Play
B: Play
C: Play
D: Play
E: Play
F: None of the auditory graphs represent the pictured graph.

Specifically, what are the reasons for your choice?

Next Question
Clear

Comments on question 6:

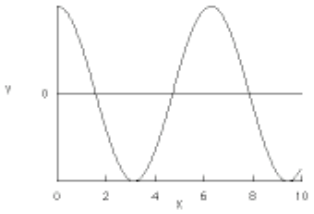
This question was similar to question 5, except that it used MIDI auditory graphs and the pitch of the drum was high for negative curvature and low for positive curvature. The five graph choices were representations of (A) sin x , (B) cos x, (C) x sin x, (D) e^{-x} sin x, and (E) e^{-x} cos x. The point of questions 5 and 6 was to compare the two auditory methods for subjects' ability to correctly match a visual graph to one of several auditory graphs.

Question #7:

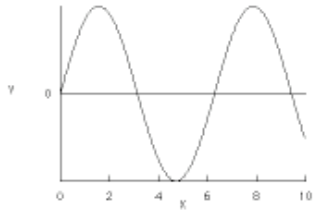
Play

Which graph pictured below best represents the auditory graph above?

A:

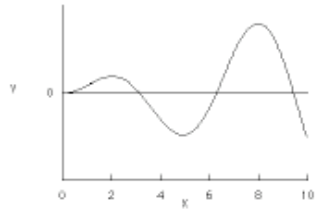


B:



C:

D:



E:

F: None of the pictured choices represent the sound.

Specifically, what are the reasons for your choice?

Next Question
Clear

Comments on question 7:

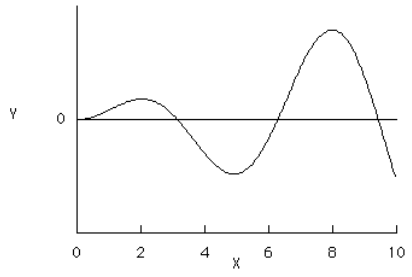
Question 7 was similar to those of 5 and 6, however, in this question, the subject was asked to match an ActiveX auditory plot of cos *x* with derivative tick-mark beats (high pitch for positive values and low pitch for negative values) to one of the five visually presented graphs.

Question #8:

Question 8 was presented identically to question 7. The auditory graph for this question was a MIDI representation of sin *x* with derivative (high for negative curvature and low for positive curvature) and an instrument change for negative values. The point

of questions 7 and 8 was to compare the two auditory methods for subjects' ability to correctly match an auditory graph to one of several visual graphs.

Question #9:



The following auditory graphs represent the graph pictured above. For each of the auditory graphs below, please give a rating on how well you feel that the sound graph represents the graph pictured above.
The scale is 1 to 5, where 1 is bad, 2 is poor, 3 is neutral, 4 is good, and 5 great.

A: 1 2 3 4 5 Play
B: 1 2 3 4 5 Play
C: 1 2 3 4 5 Play
D: 1 2 3 4 5 Play
E: 1 2 3 4 5 Play
F: 1 2 3 4 5 Play

Specifically, what are the reasons for your choices?

End
Clear

Comments on question 9:

This last question was designed to find subjects' overall preference for the different auditory graphing methods that were used. This question allowed subjects to indicate which method was their overall preference and how well they felt that the auditory graphs acted as a display method.

D.4. Summary of the Results from the Auditory Preference Pilot Test

Table D.4.1 lists the results from the test questions. Tables D.4..2-10 list subject text responses.

Table D.4.1 . Summary of Results from the Auditory Prefernce Pilot Test.

Total #	12					
	A	B	C	D	E	F
1. Gaussian curve, A = ActiveX, B=MIDI, C=both, D=neither	33%	58%	8%	0%		
2. Gaussian curve, drum beat for deriv, pitch for second deriv, A=low +, high -; B = high +, low -, C = both good, D=neither good	33%	17%	33%	17%		
3. *x* sin*x*. A=no change at 0, B= instrument change at 0, C both good, D neither good	50%	42%	0%	8%		
4. *x* sin*x*. A=ActiveX with deriv., B=MIDI with deriv and pitch change a 0; C = both, D=neither	33%	50%	0%	17%		
5. Match *e*^(sin*x*), graph (d), ActiveX sounds. a= sin *x*, b=cos*x*,, c= *x* sin *x*, d= *e*^(sin*x*),, e= *e*^(cos*x*), f=none	17%	0%	17%	58%	0%	8%
6. Match *e*^(cos*x*), graph (e), MIDI sounds. a=sin *x*, b=cos *x*, c=*x* sin *x*, d= *e*^(sin*x*),, e= *e*^(cos*x*),, f=none	8%	0%	0%	17%	58%	17%
7. Match ActiveX sound of cox(x) to picture graph (a). a=cos *x*, b=sin *x*, c=*x* sin *x*, d= *e*^(cos*x*),, e= *e*^(sin*x*), f=none	75%	0%	0%	17%	8%	0%
8. Match MIDI sound of sin(x) to picture graph (b). a=cos *x*, b=sin *x*, c=xsin(x), d= *e*^(cos*x*),, e= *e*^(sin*x*),, f=none	0%	92%	0%	0%	0%	8%

9. Likert preference of xsin(x) graph with different sound represntations 1- 5, 1 is bad, 2 is poor, 3 is neutral, 4 is good, and 5 great.

	Average	Std. Dev.
a. MIDI	3.75	0.87
b. ActiveX	3.75	1.14
c. MIDI, dx	3.08	0.79
d.ActiveX, dx	3.42	1.08
e. MIDI, 0	3.83	1.34
f. MIDI, dx, 0	3.33	1.44
Average a-f:	3.53	1.11

Table D.4.2 . Text responses for Question 1.

Subject	Comment
35	I was more familiar with sound A as a representative of motion going up and down.
36	It was harder for me to picture the second part of the curve with A. B just seemed clearer.
40	I seem to make the connection better for the higher pitches
41	The greater difference between the maximum and minimum tones made the graph easier to visualize
42	Sound A was a continuous sound, and was difficult for me to hear the steepness of the graph. Sound B seemed to help in this instance, but still needed more discontinued sounds. Also, with sound A, it was difficult to distinquish when it was at the top of the graph. I heard it better in B.
44	A sounded more continuous
46	B is like to going up the hill and seems that a car has going up to a hill and gives more gas.
47	Selection A was less dramatic than B.
48	It sounds more gradual and note quite as steep as the other
49	Both the sounds seemed rise and fall about how the visual graph. The only real difference was that they had different time scales.

Table D.4.3 . Text responses for Question 2.

Subject	Answer	Comment
35	C	I had a hard time listening and interpreting the drum beats when they were at a low pitch. I wasn't really sure of the frequency, however, I chose C because the piano and high pitch drum beat were representative of the graph for both A and B.
40	A	b is very confusing
41	C	neither changed my perception of the graph much
42	D	I actually had a hard time first distinquishing the difference between the two sounds, then I did not think either one represented the graph. The pitch of the piano tone did not seem to be as drastic as the graph previously.
44	D	The beats were confusing, if they could represent time intervals, they may be more useful.
46	C	However, they need a little bit dramatical sound when they reached at the top of the graph, I think.
47	A	The high pitch at the top of the curve best described the peak of the curve.
48	B	I could hear the first/second derivatives better in this one
49	B	The freqency of the drum seemed to match what I would expect for the dirivative.

Table D.4.4 . Text responses for Question 3

Subject	Answer	Comment
35	B	I liked how the pitch changed when the graph went below 0. I think it is important to change the sound when some major distinction (like the zero line) is involved.
36	B	I liked hearing the differece between positive and negative.
40	A	b involves too many options for the ear to play with. I did not feel that I needed a different sound for negative values.
41	A	The change from something sounding like a piano to something like an harpsichord broke up the graph a little too much
42	A	I wasn;t sure, but sound B seemed like it went down in volume as the graph decreased. OTher than that, they sounded the same.
44	D	Although A represented it more closely, the intervals for the maxima didn't seem to agree with the sound
46	B	B expressed better on the ups and downs. The sound of downs is easily recognized, but that of ups is little bit.
47	B	The change in sound when the curve went into negative values was very helpful.
48	B	Definitely because the change as you cross into negative, very helpful
49	A	Although both seem to discribe the graph correctly, I didn't like to sound when the function went negative.

Table D.4.5 . Text responses for Question 4.

Subject	Answer	Comment
35	B	The distinct sounds in B were much more clear than in A. In fact I think I just started to learn how to interpret the drum beats.
36	B	With A I couldn't hear a lot of the drum. It may be something I could learn to listen for with enough use but one first listen, I thought B was more clear.
40	A	a would be better if the drum pitch had those high harmonics for positive values instead of the negative ones.
41	D	too much information at once
42	B	In sound B, the slopes were more apparent, however, I think there needs to be more drum beats (lacking in A) Also, doesn't the time and change in pitch indicate the slope of the curve? The drum beats really don;t seem to help me.
44	A	dipicted amplitude and interval the best
46	A	A sound is good to me. I recognized that piano and drum beat are little bit hard to make a picture in my mind. Sharp pitch is better to me, but this one also needs some different sound to express the ups and downs.
47	B	Te combination of the negative value change in sound and the high pitch at the peak of the curve.
48	B	this agin, for negative change and you can pick up the slope/curvature better
49	D	Both seemed rather arbitrary in relation to the graph, at least in the dirivative department.

Table D.4.6 . Text responses for Question 5.

Subject	Answer	Comment
35	F	I started to choose E or D, but really I didn't like any of the choices. I thought that the pitch did not go high enough at the beginning of the graph or was not low enought at the end of the graph. Also, the long drawn out sound at the end created a sen
36	D	With D, I found it easier to distinguish the X ad Y (the legnth vs. the height of the curve). B and E I would have had reversed around the y axis. A I would not have pictured both curves about the same size.
41	D	sounded the closest
42	C	B and E sounded the opposite of what the graph illustrated (if a higher pitch is up, lower down) I just like the sound of C the best, however, listening to the pitches, it almost seems like the two maximums reach the same pitch, but on the graph, the second one is lower.
46	D	D sound represent the distance as time goes.
47	D	The change in sound as the curve went into the negative region of the y- axis.
48	D	But frankly, a-d sounded all the same
49	C	I think that A,C, and D seemed to do the graph justice but I think that C was the most clear

Table D.4.7 . Text responses for Question 6.

Subject	Answer	Comment
35	E	E was the only one I could trace mentally on the graph.
36	E	B, C, and D sounded upside down. E was the clearest. A had too much to listen to.
41	D	sounded closest although the drums in the background created confusion as to what was going on there
42	A	B,c,d sounded opposite to the graph and A and E sounded nearly the same.
46	E	Among them, E is the best, but I think if not considering emotion of people, drum and piano sound are hardly recognized by distance and ups and downs.
47	D	The tempo of the drum was most clear in describing the slope of the line, as was the the change in sound describing the negative values ofthe curve.
48	E	sounded not as choppy, not so harsh on the change over to negative
49	F	E seemed the closest, but the dirrivative portion seemed wrong.

Table D.4.8 . Text Responses for Question 7.

Subject	Answer	Comment
35	A	It whining sound was well represented both up and down. The drum beats added something that I could also verify my choice with.
36	A	It sounded like it started high, went down and raised just as high before going just as low down ad then having a slight upturn at the end.
42	A	The time between the minimums and maximums sounded equally apart.
46	D	I thought sharp sound would be better drum and piano sound, but in this question sharp sound do not well represent the starting point. I mean in C and D I cannot really identify the starting sound.
47	D	The pitch started high and progressively got lower. As the curve passed into the negative I heard the distinct sound. The duration of the sound also lent itself to curve D.
48	A	Because the min/max sounded the same pitch
49	A	Its the only one that seemed to fit, right down to the bit of the next period.

Table D.4.9 . Text Responses for Question 8.

Subject	Comment
35	I could hear the piano pitch go up and down and I listened to see if the pitch both times was equal. It seemed equal to me, so I picked B.
36	Went high, low, high, low with drums concentrated at the shifts from high to low.
42	I was going by the time between the original incline, to the dip and the incline again.
46	Drum and piano sound have a good effect to represent the ups and downs. If we know about which sound (drum or piano) is for ups or downs, I think I can identify these graphs.
47	Symmetrical pitch and rate for both sides of the curve.
48	Because of the apparant high rise in the beginning
49	That seemed to mostly fit B, but I don't think the derivative was correct.

Table D.4.10 . Text Responses for Question 9.

Subject	Comment
35	By this time, I have a better understanding of how the sounds work together. They all represented the graph well, it just depended on if one was interested in slope and curvature. I think the person taking this test shoud get some warm up graphs to under
36	I like hearig positive and negative. I like having pauses between notes instead of one constant sound. I like really hearing the slope. I don't like the soft drums because it's hard to differentiate them from the sound of the computer loading.
40	a is simple and pleasing to the ear. d is good and contains more information than (a) and would be easy to understand with limited explanation.
42	A:it went really slow, B:the sound was a bit annoying, but like the pace, C:I am starting to find the drum beats to be annoying, D:had an annoying pitch along with the drum beats. E:I am starting to like the discrete noises of the piano over time without the drum beats. This still may have been to slow, but I liked it the best, F:Drum beats and slow.
47	E and F were the best because they told you when the curve went into the negative region of the y-axis.
48	Again, I really like the negative value changing tone. It really helped to see the graph with my eyes closed
49	The drum used to specify the derivatives in C and F I think are rather hard to identify.

Appendix E C++ code for the DataReader program

The C++ code in this appendix relates to the DataReader program which read in an x, y data set file, converted the data to a chromatic scale, added drum beats, and changed the instrument for negative values. It then wrote the converted data to an SLG text file. There are two files, the first is the DataPane header file, and the second is the DataReader program.

E.1. DataPane.h

```
//© 1997 Steven Sahyun 9/22/97
//DataPane.h
#pragma once
#include <LPane.h>
#include <LCommander.h>
class  DataPane : public LPane, public LCommander
{
   public:
      DataPane( LStream *inStream );
      static  DataPane*  CreateDataPaneStream( LStream *inStream );
  //    static  void WriteData( int max, float *xptr, float *yptr  );
   private:
               double x[500];
               double y[500];
               int i, maxvalue;
               char fileName[64];
               double dataarray[1000];
               double *dataarray_ptr;
   protected:
      virtual void  DrawSelf( void );
                  virtual  void    ClickSelf(  const  SMouseDownEvent
&inMouseDown );
               //virtual void  SaveSelf(void);
};
```

E.2. Data Reader.cp

```
// © 1997 Steven Sahyun 9/22/97 Oregon State University
// sahyuns@ucs.orst.edu
// This code may be used with written permission from the author
// for non-commercial applications.
// written for CodeWarrior Pro 3 compiler
//DataPane.cp
#include “DataPane.h”
#include <fstream.h>
#include <string.h>
```

```
#include <ctype.h>
#include <iomanip.h>

//prototype
void itoa(int n, char s[]);
void ftoa(float n, char s[]);
void reverse(char s[]);
void convertPascalStr (Str63, char *);
void   StandardPutFile   (Str255   prompt,   Str255   defaultName,
StandardFileReply *replyPtr);
#define StandardPutFile

char *pitch( int maxvalue, double yvalue, double *yarray_ptr);
float ReadData(double *dataarray, char fileName[64]);
float WriteData(double *dataarray);
typedef char Str25[26];
typedef char Str250[251];

// ============================================================
//              create a DataPane pane from a PPob resource

DataPane*  DataPane :: CreateDataPaneStream( LStream *inStream )
{
   return ( new DataPane( inStream ) );
}

// ============================================================
//                      respond to a mouse click on the pane
void  DataPane :: ClickSelf(const SMouseDownEvent &)
{
//temporary solution until I figure out how to access the data from a
//protected class
// really want this in the cmd_Save section of DataReaderPP.cp
            dataarray_ptr = &dataarray[0];
            WriteData(dataarray_ptr);
}

// ============================================================
//                     the construct-from-stream constructor
DataPane :: DataPane( LStream  *inStream ) : LPane( inStream )
{
            dataarray_ptr = &dataarray[0];
//get file name here so that it will be part of the datapane object
//choose the file to read in
// Data structures and variables for call to StandardGetFile
            StandardFileReply replyStruct;
            SFTypeList typeList; // we're going to allow all file types
            short numTypes = -1; // allow all types of files
            StandardGetFile (nil, numTypes, typeList, &replyStruct);
            if (!replyStruct.sfGood)
            return; // user cancelled but continue anyway

            convertPascalStr (replyStruct.sfFile.name, fileName);

            ReadData( dataarray_ptr, fileName);

            //load data into object's x, y array
            maxvalue = *(dataarray_ptr++);
```

```
            for (i=0; i<maxvalue; i++)
            {
                        x[i] = *(dataarray_ptr++);
            }
            for (i=0; i<maxvalue; i++)
            {
                        y[i] = *(dataarray_ptr++);
            }

}

// ========================================================
//                        draw the pane's frame and contents
void  DataPane :: DrawSelf( void )
{
//Display the data
   ::TextFont( systemFont );
   ::TextSize( 12 );

             i = 0;
            Str250 textstring;
            Str25 numberstring;
            unsigned char *text;
            MoveTo ( 10,20);
            strcpy (textstring, "This is Data Set: ");
            strcat (textstring, fileName);
text = c2pstr (textstring); //convert C string to a pascal string
//so can write in window
            DrawString( text );

            for (i=0; i< maxvalue; i++)
            {
//generate x string to write to window, this is a bit cumbersome
                        MoveTo ( 5, i*12 + 35);
                        strcpy (textstring, " x[");
                        itoa (i, numberstring);
                        strcat (textstring, numberstring);
                        strcat (textstring, "]: ");
                        ftoa (x[i], numberstring);
                        strcat (textstring, numberstring);
                        text = c2pstr (textstring); //convert C string
//to a pascal string so can write in window
                        DrawString( text );

//generate y string to write to window, this is a bit cumbersome
                        MoveTo ( 100, i*12 + 35);
                        strcpy (textstring, " y[");
                        itoa (i, numberstring);
                        strcat (textstring, numberstring);
                        strcat (textstring, "]: ");
                        ftoa (y[i], numberstring);
            strcat (textstring, numberstring);
            text = c2pstr (textstring); //convert C string to a pascal
//string so can write in window
            DrawString( text );
            }
}
//========================================================
```

```
//                                                  functions
//this is a function used in getting the file information
void convertPascalStr (Str63 Pascalstring, char * Cstring)
{
            int length;
            int i;
            length = Pascalstring[0]; // get length byte
            for (i = 0; i < length; i++)
                        Cstring[i] = Pascalstring[i+1];
            Cstring[i] = '\0'; // don't forget the terminating null
}
// reverse: to reverse string s in place; goes with itoa, K&R p. 62
void reverse(char s[])
{
            int c, i, j;
            for (i = 0, j = strlen(s)-1; i<j; i++, j--)
            {
                        c = s[i];
                        s[i] = s[j];
                        s[j] = c;
            }
}
// FTOA: convert n to characters in string K&R p. 64
void ftoa(float nflo, char s[])
{
            int i, sign;
            int n;
            i = 0;
            nflo *= 100;// look at only 2 places past decimal
            n = (int) nflo; // chop off rest
            if ((sign = n) < 0) // record sign
                        n = -n;     // make positive
            while (i < 2)
            {
                        s[i++] = n % 10 + '0';
                        n /= 10;
            }
            s[i++] = '.';           // decimal point
            do {        // generate digits in reverse order
                        s[i++] = n % 10 + '0';  // get next digit
                        }
            while (( n /= 10) > 0);             // delete it
            if (sign < 0)
            s[i++]  = '-';
            s[i] = '\0';
            reverse(s);
}
// ITOA: convert n to characters in string K&R p. 64
void itoa(int n, char s[])
{
            int i, sign;
            if ((sign = n) < 0) // record sign
            n = -n;                             // make positive
            i = 0;
do {
// generate digits in reverse order
s[i++] = n % 10 + '0';  // get next digit
}
```

```
while (( n /= 10) > 0);              // delete it

            if (sign < 0)
                        s[i++]  = '-';
            s[i] = '\0';
            reverse(s);
}
// Reading Data from a file
//this reads x y data from a given file and puts it into a single
array.
//It returns a pointer to the array.
//the array sructure is # of items in array, x data, y data.
float ReadData(double *dataarray, char fileName[64])
{
            //get data here
            float result = 0, *result_ptr = &result;
            //float dataarray[1000], *dataarray_ptr;
            double x[500], y[500];
            int i, maxvalue;
            ifstream fin (fileName);
            if (!fin)
                        return *dataarray;
            //read the data here
            i = 0;
            while (!fin.fail())
            {
                        fin >> x[i] >> y[i];
                        i++;
            }

            fin.close();
            maxvalue = i;
dataarray[0] = maxvalue - 1;     //   Data Array 0     1    2   .... n
//n+1 n+2 ... 2n
for (i=1; i<maxvalue; i++)          //  value      max  x0  x1 ... xn-1
//y0  y1  ... y2n-2
            {
                        dataarray[i] = x[i-1];
            }
            for (i= 0; i<maxvalue; i++)
            {
                        dataarray[i+ maxvalue] = y[i];
            }
            return *dataarray;
}

// Writing Data to a file
float WriteData (double *dataarray)
{
            double x[500], y[500];
            //char fileName[64];
            int i, maxvalue;
                        //load data into x, y arrays
            maxvalue = *(dataarray++);
            for (i=0; i<maxvalue; i++)
            {
                        x[i] = *(dataarray++);
            }
```

```
            for (i=0; i<maxvalue; i++)
            {
                        y[i] = *(dataarray++);
            }

Str255 prompt = "\pSave file as:"; // \p tells the compiler to
//make a Pascal string
            Str255 default_name = "\pData.slg";
            StandardFileReply replyStruct;
            StandardPutFile (prompt, default_name, &replyStruct);

//          if (!replyStruct.sfGood)
//                      return *dataarray; // user cancelled; don't
save

// trying to put a name for the data set; for some reason the save dlg
//isn't working
//convertPascalStr (replyStruct.sfFile.name, fileName);
            ofstream fout ("Data.slg"); //ofstream fout (fileName);
//          if (!fout)
//                      return *dataarray;

//this section converts the data and outputs it in SLG text MIDI format
            int  bar, beat, durbeat;
            int beatpart, durbeatpart, TIMEBASE = 100;
            float temp;
            float maxx = 0;
            float maxy = 0, yold = y[0];
            float slope1, slope2;
            float curvature;
            float minx = 9999999;
            float miny = 9999999;
            float zeropoint = 0; // in case of negative y values
            int instrument = 4; //electric piano - works well as sound
does //not decay
            int neginstrument = 6; //harpsichord - for negative values
            int ytickinstrument = 47; //melodic tom - seemed to work
best for //sound as is short
// c2 for - curve, c3 for no curvature, c4 for + curve

            char *note; //pointer to start of the note array value for
the x //data set
char dnote[4]; // "" for the derivative's data set
//data is loaded into function's array here, x is for time, y is for
//pitch
for (i = 0; i < maxvalue; i++)
{
temp = x[i];
if (maxx < temp)
maxx = temp;
if (minx > temp)
minx = temp;
temp = y[i];
if (maxy < temp)
maxy = temp;
if (miny > temp)
miny = temp;
}
```

```
// deal with negative y values by y = y+abs(minimum y), then do a
//program change piano/harpsicord around y = abs(min y)
if (miny < 0)
{
for (i = 0; i<maxvalue; i++)
{
y[i] -= miny; // subtract a negative = shift data set //into positive
//territory
}
zeropoint -= miny; //want to set the new 0
maxy -= miny; //shift max and min values by min value
miny -= miny;
}
//header, uses timebase of 100 for easy calculations
fout     <<     "%MIDIFILE\n@MThd\n@FORMAT     0\n@TIMEBASE
"<<TIMEBASE<<"\n@END\n";
fout << ";----------------------------------\n@MTrk 1\n";
//instrument is written here
if (y[0] >= zeropoint )
fout  <<  "001|1|000    1:PROG    "  <<  instrument  <<  "\n"; //main data
//tone on midi chan 1
else
fout << "001|1|000  1:PROG  " << neginstrument << "\n";
//if first point is negative switch to negative instrument
fout << "001|1|000  2:PROG  " << ytickinstrument << "\n"; //dx/dy info
on midi chan 2
fout << setiosflags (ios::fixed | ios :: right) << setprecision(0) <<
setfill('0'); // make the output look pretty

// sound is written here, convert into SLG format for times and pitch
// initial slope beat at start
//checking the curvature
slope2 = (y[1] - y[0])/(x[1] - x[0]);
curvature = slope2;
//may need to put an if statement here limiting sensitivity
if  (curvature > 0)  //positive curvature dy2/dx2 > 0; //concave; lower
//value, like water in a bowl
strcpy (dnote, "C3");
else if (curvature < 0)    //negative curvature dy2/dx2 < 0; //convex,
//higher value, like water hitting a hat
strcpy (dnote, "C5");
else
strcpy (dnote, "C4"); //line; no curvature
//write the beat info here
fout << "001|1|000  2:" << dnote << "  127     0|020\n";
//data notes and beat notes
for (i = 0; i < maxvalue; i++)
{
//sets the duration of the note;
if (i+1 == maxvalue)  //need to worry about last data point
{
durbeatpart = (int) (2000*(x[i] - x[i-1])/(maxx -
minx))%TIMEBASE;//2000 is the total time, Timebase is for the beatpart
durbeat = (int) (20*(x[i]- x[i-1])/(maxx - minx))%4;
}
else
{
durbeatpart = (int) (2000*(x[i+1] - x[i])/(maxx -
```

```
minx))%TIMEBASE;//2000 is related to the total time, Timebase is for
the
beatpart and is same as timebase
durbeat = (int) (20*(x[i+1]- x[i])/(maxx - minx))%4;
}
beat = (int) (2000*(x[i]- minx)/(maxx - minx))%(4*TIMEBASE); // for
intervals less than a beat,
//each beat has 4 parts
beatpart = beat%100; //kludge because I couldn't figure out //how to
//add this in the previous line
beat = (int) (20*(x[i]- minx)/(maxx - minx))%4 + 1;
bar = (int) 20*(x[i] - minx)/(maxx - minx)/4 + 1;
note = pitch( maxvalue, y[i], &y[0]); //put the values of //the
returned pitch pointer value into note pointer
// check to see if crossed zeropoint, if so change instrument.
if (y[i] <= zeropoint && y[i+1] > zeropoint)
fout << setw(3) << bar <<"|"<< beat << "|" << setw(3) << beatpart << "
1:PROG  " << instrument << "\n";
//switch to //positive instrument
if (y[i] >= zeropoint && y[i+1] < zeropoint)
fout << setw(3) << bar <<"|"<< beat << "|" << setw(3) << beatpart << "
1:PROG  " << neginstrument << "\n";
//switch to //negative instrument
//check to see if have passed crossed a Cn value, if so, check slope
and
//print out a beat
if (i > 0 && i < maxvalue-1)  // putting in the derivative //beat here,
//don't take 1st or last points
{
 float beatspan = 0.099; // 1/#of notes wanted in 5 //octaves, less a
//fudge factor, best is normally 0.099
 if ((y[i] - yold)/maxy >= beatspan || (y[i] - yold)/maxy <=
(-1*beatspan)) //sounds span 5 octaves. 2 notes per octave, so check if
crossed a differece point (less a little fudge factor)
{
yold = y[i];

//checking the curvature
slope1 = (y[i] - y[i-1])/(x[i] - x[i-1]);
slope2 = (y[i + 1] - y[i])/(x[i + 1] - x[i]);
curvature = slope2 - slope1;
//may need to put an if statement here limiting sensitivity
if  (curvature > 0)  //positive curvature dy2/dx2 > 0;
//concave lower value, like water in a bowl
strcpy (dnote, "C3");
else if (curvature < 0)   //negative curvature //dy2/dx2 < 0;
//convex, higher value, like water hitting a hat
strcpy (dnote, "C5");
else
strcpy (dnote, "C4"); //line; no curvature
//write the beat info here
fout << setw(3) << bar <<"|"<< beat << "|" << setw(3) << beatpart << "
2:" << dnote << "  127     0|020\n";
}
}
//print out x, y data point
fout << setw(3) << bar <<"|"<< beat << "|" << setw(3) << beatpart << "
1:" << note << "  127   ";
```

```
fout << durbeat << "|" << setw(3) << durbeatpart << "\n";
}
fout << "@END\n";
return *dataarray;
}
char *pitch( int maxvalue, double yvalue, double *yarray_ptr)
{
double yarray[500];
static char note[4] = "   ";
char *charvalue = "";
int value, i;
double ymax;
ymax = 0;
for (i = 0; i < maxvalue; i++)
{
yarray[i] = *(yarray_ptr + i);
if (ymax < yarray[i])
ymax = yarray[i];
}
value = (int) (yvalue*60/ymax)%12;
//turn into a switch function for case ...
switch (value)
{
case 13:
strcpy (note, "Z");//kludge:for some reason it skips //the first case
break;
case 0:
strcpy (note, "C");
break;
case 1:
strcpy (note, "C#");
break;
case 2:
strcpy (note, "D");
break;
case 3:
strcpy (note, "D#");
break;
case 4:
strcpy (note, "E");
break;
case 5:
strcpy (note, "F");
break;
case 6:
strcpy (note, "F#");
break;
case 7:
strcpy (note, "G");
break;
case 8:
strcpy (note, "G#");
break;
case 9:
strcpy (note, "A");
break;
case 10:
strcpy (note, "A#");
```

```
break;
case 11:
strcpy (note, “B”);
break;
default:
strcpy (note, “C”);
}
value = (int) (yvalue*60/ymax)/12;
switch (value)
            {
            case 0:
            strcpy (charvalue, “2”);
            break;
            case 1:
            strcpy (charvalue, “3”);
            break;
            case 2:
            strcpy (charvalue, “4”);
            break;
            case 3:
            strcpy (charvalue, “5”);
            break;
            case 4:
            strcpy (charvalue, “6”);
            break;
            default:
            strcpy (charvalue, “7”);
            }
strcat (note, charvalue);
return note;
}
```

Appendix F PERL Code for Studies Using the World Wide Web

F.1. Overview

The PERL code in this appendix relates to several programs used to generate the Web pages and record the answers provided by the subjects. Namepage recorded a log of subjects who participated in the studies. It also assigned a code number for each subject and randomly chose which graph type group they would be in. Surveyrecord appended subject's text responses to the survey and pre-test pages to a file called "surveylong" and passed the rest of the information to the first test question page it created from a question file. Temprecord generated the question HTML pages from a question file and appended the answers to a file called "finalresult".

F.2. Namepage

This script appends the name of the subject and a code number to a testlog file, and assigns them to one of three graph categories. It then loads and displays the survey Web pages.

```
#Namepage, ©1997 Steven Sahyun, Oregon State University
#!/usr/local/bin/perl
require '../cgi-lib.pl';
&ReadParse(*in);
#Variables that are passed from name page
$name=$in{'name'};
#Limit input size
$max_string_length = 40; #sets the max length for the test string
$test = $name;
$counter = 0;
while ($test ne "")
{
            chop $test;
            $counter++;
}
if ($counter > $max_string_length)
{
            $name = ""; #if length fails, give null value
```

```
}

$school_code=$in{'SCHOOL_CODE'};

#Limit input size
$max_string_length = 4; #sets the max length for the test string
$test = $school_code;
$counter = 0;
while ($test ne "")
{
            chop $test;
            $counter++;
}
if ($counter > $max_string_length)
{
            $school_code = ""; #if length fails, give null value
}

#Page locations
$FILEPAGE="http://www.physics.orst.edu/~sahyun/survey/quest/namepage.ht
ml";
$NEXTFILEPAGE="/usersA/sahyun/public_html/survey/quest/survey.html";
#Get a student code number ...
open(getcode, "testlog");
            while (<getcode>)
            {
                        $lastline = $_;
            }

close(getcode);
#Get the last number of listing (first item in list array) and
increment
chop($lastline);
($oldcode, $oldname, $oldschool) = split(/  /,$lastline);
$code = $oldcode;
$code++;

#Send them back to the page if no selection
if($name eq '' || $school_code eq '')
{
        print "Location: $FILEPAGE\n\n";
}
#Record name and codes and move to the start of test
else
{
            #Record student and code number in testlog if not 000
#           if ($school_code ne '000')
#           {
                        open(OUT, ">>testlog");
            print OUT "\n".$code."*".$name." *".$school_code;
                        close(OUT);
#       }
            open(IN, $NEXTFILEPAGE);
            print "Content-type: text/html\n\n";
            while (<IN>)
            {
            #check to find the form field to add the code number
                        $line = $_;
```

```
                        chop($line);
                        if ($line eq "<!--code-->")
                        {
                        print "<input name=\"code\" type=\"hidden\"
value=\"".$code."\">\n";
                print "<input name=\"composite\" type=\"hidden\"
value=\"*S:\">\n";
#S: is to mark the start of the survey
                        }
                        else
                        {
                                    print $_;
                        }
            }
            close(IN);
}
```

F.3. Surveyrecord

This script appends subject's text responses to the survey and pre-test pages and passes the rest of the information to the first test question page that it creates from a question file.

```
      # Surveyrecord ©1997 Steven Sahyun, Oregon State University
      #!/usr/local/bin/perl
      require '../cgi-lib.pl';

      &ReadParse(*in);
      #Variables that are passed from page (the answer for the
question)
      $code=$in{'code'};
      $composite = $in{'composite'};
      $gender = $in{'gender'};
      $age = $in{'age'};
      #Limit input size
      $max_string_length = 3; #sets the max length for the test string
      $test = $age;
      $counter = 0;

      while ($test ne "")
      {
              chop $test;
              $counter++;
```

```
	}
	if ($counter > $max_string_length)
	{
		$age = “000”; #if length fails, give age a 0 value
	}

	$hsphys = $in{‘hsphys’};
	$cphys = $in{‘cphys’};

	#free response answers
	$pcours = $in{‘physcourses’};
	$ocours = $in{‘othercourses’};
	$ograph = $in{‘othergraph’};
	$mus = $in{‘music’};
	$diff = $in{‘difficulty’};
	$composite = $composite.” *”.$gender.” *”.$age.” *”.$hsphys.”
*”.$cphys.” *M:”;

	#to record total time to take the test
	$starttime = time;

	#Question locations
	$NEXTFILEPAGE=“/usersA/sahyun/public_html/survey/quest/firstq.htm
l”;

	#open file to write the longer survey answers
	open(OUT, “>>surveylong”);
	print OUT $code.” *pcours: *”.$pcours.” *ocours: *”.$ocours.”
*ograph: *”.$ograph.” *mus: *”.$mus.” *diff: *”.$diff.”\n”;
	close(OUT);
	#get first question page and write added variables to it
	open(IN, “$NEXTFILEPAGE”);
	print “Content-type: text/html\n\n”;
	while (<IN>)
	{
	#check to find the form field to add the code number and
composite score
		$line = $_;
		  chop($line);
```

```
                    if ($line eq "<!--code-->")
            {
      print    "<input    name=\"code\"    type=\"hidden\"
value=\"".$code."\">\n";
      print        "<input        name=\"starttime\"
type=\"hidden\"value=\"".$starttime."\">\n";
      print    "<input    name=\"composite\"    type=\"hidden\"
value=\"".$composite."\">\n";
            }
            else
            {
                    print $_;
            }
      }
      close(IN);
```

F.4. Temprecord

This script generates the question pages from a question file. The question file is a HTML fragment that contains the text of the question, the answers, and <!—code --> and <!—graph--> text. The script inserts the appropriate graph and codes from previous answers, adds a header and footer to create a Web page for the subject.

```
#Temprecord © 1997 Steven Sahyun, Oregon State University
#!/usr/local/bin/perl
require '../cgi-lib.pl';
&ReadParse(*in);
#Variables that are passed from page (the answer for the question)
$code=$in{'code'};
$composite=$in{'composite'};
$number=$in{'number'};
$answer=$in{'answer'};
$starttime=$in{'starttime'};

#Number of questions in the test
$numquest = 14;

#Question locations
$FILEPAGE="/usersA/sahyun/public_html/survey/quest/mtq".$number.".html"
;
$NEXTFILEPAGE="/usersA/sahyun/public_html/survey/quest/mtq".($number+1)
."".html";
$thankyou="http://www.physics.orst.edu/~sahyun/survey/quest/thankyou.ht
ml";
```

```
#Send them back to the page if no selection
if($answer eq ‘’)
{
        open(IN, “$FILEPAGE”);
        &output;
            close(IN);
}
#Record answer and move to the next question
else
{
#If anwered last question then record final answer and go to Thankyou
page
            if($number == $numquest)
            {
                        $etime = time - $starttime;
                        $composite = $composite.” *”.$number.”
*”.$answer.” *etime: *”.$etime;
                        open(OUT, “>>finalresult”);
                        print OUT $code.”  “.$composite.”\n”;
                        close(OUT);
                        print “Location: “.$thankyou.”\n\n”;
            }
#otherwise move on to the next question
            else
            {
            open(IN, $NEXTFILEPAGE);
                        $composite = $composite.” *”.$number.”
*”.$answer;
                        $number++;
            &output;
            close(IN);
            }
}

sub output
{
print “Content-type: text/html\n\n”;
print “<html>\n”;
print “<h1><TITLE>Graph Test Question “.$number.”</TITLE></h1>\n”;
print “<body>\n”;
print “<head>\n”;
print “<!-- Author: Steve Sahyun (sahyun\@physics.orst.edu) -->\n”;
print “</head>\n”;
print “<h1><center>Question \#”.$number.”: </center></h1>\n”;
print “<p>\n”;

while (<IN>)
{
   $line = $_;
   chop($line);
   if ($line eq “<!--graph-->“)
   {
print “<p>\n”;
print “<center>\n”;
print “<img
src=\”http://www.physics.orst.edu/~sahyun/survey/quest/mtq”.$number.”pi
c.gif\” align=bottom alt=\”Graph for question “.$number.”\”>\n”;
```

```
print “</center>\n”;
print “<p>\n”;
print “<center>\n”;
print “<EMBED
SRC=\”http://www.physics.orst.edu/~sahyun/survey/quest/mtq”.$number.”sn
d.mov\” HEIGHT=24 WIDTH=200 CONTROLLER=TRUE LOOP=FALSE
AUTOPLAY=FALSE>\n”;
print “</center>\n”;
print “<p>\n”;
   }
   elsif ($line eq “<!--code-->“)
   {
print “<br>\n”;
print “<FORM METHOD=\”POST\”
#ACTION=\”http://www.physics.orst.edu/cgi-bin/sahyun/temprecord\”>\n”;
print “<input name=\”code\” type=\”hidden\” value=\””.$code.”\”>\n”;
print “<input name=\”starttime\” type=\”hidden\”
value=\””.$starttime.”\”>\n”;
print “<input name=\”composite\” type=\”hidden\”
value=\””.$composite.”\”>\n”;
print “<input name=\”number\” type=\”hidden\”
value=\””.$number.”\”>\n”;
   }
   else
   {
            print $_;
   }
}
print “<p>\n”;
print “</form>\n”;
print “<p>\n”;
print “Questions about the test?  Send e-mail to: <a
href=\”mailto:sahyun\@physics.orst.edu\”>\n”;
print “<address>sahyun\@physics.orst.edu</address></a>\n”;
print “<p>\n”;
print “Last modified September 11, 1997.\n”;
print “</body>\n”;
print “</html>\n”;
}
      #The End!!!
```