

Good Vibrations: Music Resounds with Physics! – Individual Work Scoring Sheet

Student Name: _____

Place a score (1-4) in each row corresponding to the student's college readiness level.

Exceeding College Ready (4): Substantially exceeds the performance expectations**College Ready (3):** Shows proficiency in all of the performance expectations**Approaching College Ready (2):** Meets only some of the performance expectations**Initiating College Ready (1):** Does not yet meet the performance expectations

KEY COGNITIVE SKILLS	Student's Self-Assessment	Instructor's Score
Intellectual Curiosity (engages in scholarly inquiry and dialogue; accepts constructive criticism and revises personal views when valid evidence warrants)		
Reasoning (considers arguments, conclusions of self and others; constructs well-reasoned arguments to explain phenomena, validate conjectures, support positions; gathers evidence to support arguments, findings, reasoning; supports or modifies claims based on inquiry)		
Problem Solving (collects evidence and data systematically and directly relates them to solving a problem)		
Academic Behaviors (self-monitors learning needs and seeks assistance when needed; uses good study habits; strives for accuracy and precision; perseveres to complete and master tasks)		
Work Habits (works independently)		
Academic Integrity (includes the ideas of others and the complexities of the debate, issue, or problem)		
FOUNDATIONAL SKILLS	Student's Self-Assessment	Instructor's Score
Writing Across the Curriculum (writes clearly and coherently using standard writing conventions)		
Research Across the Curriculum (synthesizes and organizes information effectively; designs and presents an effective product)		
Use of Data (identifies patterns/departures among data; uses statistical, probabilistic skills for planning, collecting, analyzing, interpreting data; communicates findings in a variety of formats)		
Technology (uses technology appropriately to gather, organize, manage, and analyze information; uses technology to communicate, display findings in a clear and coherent manner)		
SCIENCE STANDARDS	Student's Self-Assessment	Instructor's Score
Nature of Science: Scientific Ways of Learning and Thinking (uses cognitive skills; designs, conducts scientific investigations; uses collaborative, safe methods; conveys scientific info)		
Foundational Skills: Scientific Applications of Mathematics (understands basic math conventions and symbols; uses appropriate problem solving, SI units, and significant digits)		
Foundational Skills: Scientific Applications of Communication (demonstrates appropriate reading and writing practices for science; presents scientific information accurately)		
Physics (understands basic oscillatory motion, simple harmonic motion, the difference between transverse and longitudinal waves, the properties and behavior of sound waves, and wave terminology: wavelength, period, frequency, and amplitude)		

See reverse for
comments.

Score	College Readiness Level
49-56	Exceeding College Ready
41-48	College Ready
21-40	Approaching College Ready
0-20	Initiating College Ready

Total Score: _____

Grade: _____

See Scoring Guide for grade
conversion chart.

Good Vibrations: Music Resounds with Physics! – Group Work Scoring Sheet

Group Name(s): _____

Place a score (1-4) in each row corresponding to the student’s college readiness level.

- Exceeding College Ready (4):** Substantially exceeds the performance expectations
- College Ready (3):** Shows proficiency in all of the performance expectations
- Approaching College Ready (2):** Meets only some of the performance expectations
- Initiating College Ready (1):** Does not yet meet the performance expectations

KEY COGNITIVE SKILLS	Group’s Assessment	Instructor’s Score
Reasoning (constructs well-reasoned arguments to explain phenomena, validate conjectures, support positions; gathers evidence to support arguments, findings, reasoning; supports or modifies claims based on inquiry)		
Problem Solving (develops and applies multiple strategies to solve problems; collects evidence and data systematically and directly relates them to solving a problem)		
Academic Behaviors (strives for accuracy and precision; perseveres to complete and master tasks)		
Work Habits (works collaboratively)		
Academic Integrity (includes the ideas of others and the complexities of the debate, issue, or problem)		
FOUNDATIONAL SKILLS	Group’s Assessment	Instructor’s Score
Writing Across the Curriculum (writes clearly and coherently using standard writing conventions)		
Research Across the Curriculum (synthesizes and organizes information effectively; designs and presents an effective product; presents final product)		
Use of Data (identifies patterns/departures among data; uses statistical, probabilistic skills for planning, collecting, analyzing, interpreting data; communicates findings in a variety of formats)		
Technology (uses technology appropriately to gather, organize, manage, and analyze information)		

Score	College Readiness Level
32-36	Exceeding College Ready
27-31	College Ready
13-26	Approaching College Ready
0-12	Initiating College Ready

Total Score: _____

Grade: _____

See Scoring Guide for grade conversion chart.

Comments:

Good Vibrations: Music Resounds with Physics! – Scoring Guide for Individual Work

Note: The letters and numbers of the skills below refer to their designation in the College and Career Readiness Standards.

KEY COGNITIVE SKILLS

A. Intellectual Curiosity

1. Engage in scholarly inquiry and dialogue.

College Ready Description: Student identifies what he or she knows, does not know, and wants to know regarding the common attributes of string instruments and the common attributes of wind instruments.

Evidence for Scoring: Student identifies the length or size of the instrument (either kind), the tension of the string(s) in a string instrument, or the relative weight or mass of those string(s).

2. Accept constructive criticism and revise personal views when valid evidence warrants.

College Ready Description: Student integrates new information into his or her arguments when his or her thought processes are incorrect or incomplete.

Evidence for Scoring: When a classmate correctly and logically explains why the student is incorrect, the student is open to change.

B. Reasoning

1. Consider arguments and conclusions of self and others.

College Ready Description: Student adequately applies logic to analyze patterns and descriptions and to thoughtfully evaluate conclusions regarding important design elements of musical instruments.

Evidence for Scoring: After observing the bass strings on a guitar or piano, student reasons that the resonant pitch is affected by factors of both tension and weight (mass), but differently: more tension produces higher pitches, while more mass produces lower pitches.

2. Construct well-reasoned arguments to explain phenomena, validate conjectures, or support positions.

College Ready Description: Student advances a logical solution clearly based in original thought and reflective of scientific facts, rather than opinions, regarding resonance in musical instruments. Student submits a report clearly describing the hypothesis, data, results, and conclusions related to the factors affecting musical resonance in strings and tubes.

Evidence for Scoring: Student might propose that the vibrating medium in a string instrument is the string itself, whereas, in a wind instrument that medium is not the tube (as many might suppose) but the air within it. Student's report documents how the original research identified length, tension, and mass as factors to investigate and how the subsequent experiments varied just one of those factors at a time, tabulating the resulting resonant frequencies and fitting the data to mathematical functions describing the dependencies.

3. Gather evidence to support arguments, findings, or lines of reasoning.

College Ready Description: Student uses relevant data to support descriptions of patterns in the prevailing designs of real string or wind instruments.

Evidence for Scoring: Student may cite data indicating how octave intervals on a guitar are related to fret distances or how the lengths of pipes in a pipe organ relate to those pipes' resonant frequencies.

4. Support or modify claims based on the results of inquiry.

College Ready Description: Student systematically reviews and checks strategies and calculations throughout the investigation.

Evidence for Scoring: In graphing/calculating the dependence on tension, the student reviews and checks the calculations to be sure that it's not a linear mathematical relationship.

C. Problem Solving

3. Collect evidence and data systematically and directly relate them to solving a problem.

College Ready Description: Student clearly describes the data collection procedure and explains how that data supports the modeling process. Student produces relevant charts, graphs, and/or diagrams accurately, including scale, labeling, units, and organization.

Evidence for Scoring: Student reports on the apparatus used to vary length in the string tests: that first, the string was weighed (and its mass per unit length calculated from that), then the string was extended horizontally with a known tension produced by a weight hanging from it over a pulley, etc. Student graphs data for resonant frequencies against length (tension and weight having been held constant). The shape of this graph would be telltale—supportive of the accompanying regression analysis for best-fitting curve.

D. Academic Behaviors

1. Self-monitor learning needs and seek assistance when needed.

College Ready Description: Student keeps a mindful eye on his or her integration of knowledge as it progresses and is able to ask fellow students and the instructor for help.

Evidence for Scoring: Student is comfortable admitting he or she does not know an answer and is willing to re-examine the material to relearn.

2. Use study habits necessary to manage academic pursuits and requirements.

College Ready Description: Student looks over the material he or she needs to incorporate and tries to come up with a logical approach to complete the task in the allotted time.

Evidence for Scoring: Student is able to pool ideas that were generated within the group during the brainstorming stage in order to design and conduct experiments to measure how various factors affect the resonant pitch of a vibrating string.

3. Strive for accuracy and precision.

College Ready Description: Student carefully and correctly collects and reports experimental data throughout all stages of planning and execution.

Evidence for Scoring: Student includes all trial runs of the tension variation tests, even those that were deemed to be near outliers and not used in the final curve fitting.

4. Persevere to complete and master tasks.

College Ready Description: Student submits a report that reflects thorough understanding of each element of the task and meets all requirements of the assignment.

Evidence for Scoring: Student's report not only tabulates, graphs, and applies curve fit to the three analyses for each type of resonating system, it should also document the preliminary research and decision making that led to the tests conducted. The post-analysis discussion should address how the longitudinally resonating spring is a direct analogy of how air itself resonates in the tube of a wind instrument.

E. Work Habits

1. Work independently.

College Ready Description: Student can work though the problems by themselves.

Evidence for Scoring: Student does not wait until the group work to start thinking about the activity.

F. Academic Integrity

3. Include the ideas of others and the complexities of the debate, issue, or problem.

College Ready Description: Student is able to evaluate and incorporate, if appropriate, the contributions of others to generate a more complete and coherent explanation to address the problem at hand.

Evidence for Scoring: When classmates share ideas after brainstorming, student actively engages with other students' suggestions and attempts to incorporate them into a series of experiments to perform.

FOUNDATIONAL SKILLS

B. Writing Across the Curriculum

1. Write clearly and coherently using standard writing conventions.

College Ready Description: Student uses appropriate terminology and data expression to communicate information in a concise manner. Student submits a report that has few or no errors in grammar, mechanics, punctuation, and spelling.

Evidence for Scoring: Student makes proper use of the terms node vs. antinode, frequency vs. wavelength, weight vs. mass, and weight per meter vs. linear mass density.

C. Research Across the Curriculum

5. Synthesize and organize information effectively.

College Ready Description: Student collects and organizes experimental data in an orderly and strategic manner. Student effectively sequences the presentation of experimental data to support the final conclusion(s).

Evidence for Scoring: Student organizes data for length dependency in a table listing it along with the resonant frequencies produced and likewise for the data from tension dependency tests, etc. Student reports data for each of the factors investigated separately (along with their graph) prior to presentation of the regression implying the mathematical model, so that the reader would almost surmise the model from the shape of the graph. The regression result would seem eminently plausible—almost necessary—when then derived.

6. Design and present an effective product.

College Ready Description: Student follows all specifications of the assignment.

Evidence for Scoring: Student begins with the initial research, as directed, then identifies the factors affecting resonance that bear investigating. Student then devises and conducts those investigations, analyzes the results both graphically and statistically and proposes a mathematical model accounting for the effects of the factors. Student then extends by recognizing the analogy between longitudinally resonating springs and longitudinally resonating air particles (i.e., resonant sound tones).

D. Use of Data

1. Identify patterns or departures from patterns among data.

College Ready Description: Student adequately identifies relevant trends in the graphs as well as patterns in the instruments studied in the preliminary research.

Evidence for Scoring: Student may note that guitar strings producing lower resonant pitches tend to be both looser and thicker (heavier) than strings producing higher resonant pitches. Student may then observe in the experimental data that lower tension and higher linear mass density each (separately) lower the resulting resonant frequencies.

2. Use statistical and probabilistic skills necessary for planning an investigation, and collecting, analyzing, and interpreting data.

College Ready Description: Student uses appropriate best fit regression techniques and data ranges to quantify the relationships indicated in the resonance data.

Evidence for Scoring: Student's regression may not reveal much in the first couple of trials (i.e., all may appear proportional or inversely proportional), but when the factor being studied is varied widely enough, the mathematical dependency becomes clearer.

3. Present analyzed data and communicate finding in a variety of formats.

College Ready Description: Student composes a written report that adequately details experimental research to determine some factors affecting resonance in strings and springs.

Evidence for Scoring: Student's report specifies which factor is being varied (and which others controlled), the degree of precision, the number of trials, and any outliers discarded.

E. Technology

1. Use technology to gather information.

College Ready Description: Student uses appropriate devices to accurately measure physical properties.

Evidence for Scoring: Student's tension analysis uses a varying amount of weight on a pulley to create a known source of constant tension and on the electronic vibration generator to create a known source of steady frequency. Likewise, student's length analysis uses a string or spring of varying length, etc.

2. Use technology to organize, manage and analyze information.

College Ready Description: Student utilizes technology to analyze the experimental data.

Evidence for Scoring: Student might use a spreadsheet both to graph each factor's data and then to perform regression to determine the mathematical model best fitting that data.

3. Use technology to communicate and display findings in a clear and coherent manner.

College Ready Description: Student utilizes technology to effectively present information and data graphically, textually, and mathematically.

Evidence for Scoring: Student might use a spreadsheet for presenting the tables of data (with calculations) and then use a word processing program for the report/discussion itself.

4. Use technology appropriately.

College Ready Description: Student thoughtfully identifies when technology may not be necessary or appropriate to communicate findings.

Evidence for Scoring: Student makes a careful hand drawing of each apparatus used in the Investigating trials, with all dimensions/aspects labeled clearly and consistently but using a spreadsheet to present the graphical and analytical results/conclusions and using a word processor for the report/discussion itself.

SCIENCE STANDARDS

I. Nature of Science: Scientific Ways of Thinking and Learning

A.4. Cognitive skills in science.

College Ready Description: Student relies on reproducible observations of empirical evidence when constructing, analyzing, and evaluating explanations of natural events and processes.

Evidence for Scoring: Student critically thinks about the ideas that are being addressed and logically comes to a conclusion. Student does not blindly believe his or her fellow classmates' claims but questions the validity of those claims.

B.1. Scientific inquiry.

College Ready Description: Student designs and conducts scientific investigations in which hypotheses are formulated and tested.

Evidence for Scoring: Student sets up an experiment to collect data for determining patterns of transverse standing waves in strings for various combinations of string length, tension, and mass. Student uses mathematical curve fitting to show the relationship between the waves and the string characteristics.

C.1, 3. Collaborative and safe working practices.

College Ready Description: Student collaborates on joint projects. Student demonstrates skill in the safe use of a wide variety of apparatuses, equipment, techniques, and procedures.

Evidence for Scoring: Student actively participates in the discussions with fellow classmates as well as the instructor. Student asks and answers questions within his or her group regarding their experiment.

E.1, 2. Effective communication of scientific information.

College Ready Description: Student uses several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic. Student uses essential vocabulary of the discipline being studied.

Evidence for Scoring: Student converses with fellow classmates about the activity. Student provides clear explanation of interference to their classmates, correctly using words like wavelength and frequency.

II. Foundation Skills: Scientific Applications of Mathematics

A.3, 4, 7. Basic mathematics conventions.

College Ready Description: Student understands ratios, proportions, percentages, and decimal fractions, and translates from any form to any other. Student uses proportional reasoning to solve problems and uses calculators, spreadsheets, computers, etc., in data analysis.

Evidence for Scoring: Student uses a graphing calculator or computer to make graphs of his or her data. Student creates graphs from the data collected in his or her group's experiment.

B.1, 2. Mathematics as a symbolic language.

College Ready Description: Student carries out formal operations using standard algebraic symbols and formulae. Student represents natural events, processes, and relationships with algebraic expressions and algorithms.

Evidence for Scoring: Student represents the relationship between the square of the resonant frequencies and mass density when all other variables are held constant as an algebraic expression.

D.1. Scientific problem solving.

College Ready Description: Student uses dimensional analysis in problem solving.

Evidence for Scoring: Student uses dimensional analysis (i.e., determining whether the units across a mathematical relationship are consistent) to connect the mathematical relationships resulting from the graphical analysis to one another and validate the functions chosen as best fits.

F.1, 2. Scientific measurement.

College Ready Description: Student selects and uses appropriate Standard International (SI) units and prefixes to express measurements for real-world problems. Student uses appropriate significant digits.

Evidence for Scoring: Student makes measurements with various devices and records the data with the correct number of significant digits. Student uses scales to measure masses and meter sticks to measure length.

III. Foundation Skills: Scientific Applications of Communication

A.1. Scientific writing.

College Ready Description: Student uses correct applications of writing practices in scientific communication.

Evidence for Scoring: Student presents his or her knowledge in the form of a report. Student says in words what factors affect the resonant frequencies of a longitudinally vibrating spring.

B.2, 3. Scientific reading.

College Ready Description: Student sets up apparatuses, carries out procedures, and collects specified data from a given set of appropriate instructions. Student recognizes scientific and technical vocabulary in the field of study and uses this vocabulary to enhance clarity of communication.

Evidence for Scoring: Student follows the instructions in the Student Notes for setting up the experiment.

C.1. Presentation of scientific/technical information.

College Ready Description: Student prepares and presents scientific/technical information in appropriate formats for various audiences.

Evidence for Scoring: Student presents his or her results from an experiment. Student presents his or her mathematical conclusions, a demonstration of those conclusions, and a brief explanation of how those principles are applied to real musical instruments.

VIII. Physics**G.1, 2, 3, 4. Oscillations and waves.**

College Ready Description: Student understands basic oscillatory motion, simple harmonic motion, the difference between transverse and longitudinal waves, and the properties and behavior of sound waves. Student understands wave terminology: wavelength, period, frequency, and amplitude.

Evidence for Scoring: Student describes waves using terms such as wavelength, period, frequency, and amplitude. Student identifies examples of oscillatory motion. Student describes the motion of the medium as compared to the wave motion for both transverse and longitudinal waves.

Good Vibrations: Music Resounds with Physics! – Scoring Guide for Group Work

Note: The letters and numbers of the skills below refer to their designation in the College and Career Readiness Standards.

KEY COGNITIVE SKILLS**B. Reasoning****2. Construct well-reasoned arguments to explain phenomena, validate conjectures, or support positions.**

College Ready Description: Group demonstrates careful consideration of multiple key factors that could affect resonance frequencies in strings and tubes. Group adequately supports, with valid observations and analyses, descriptions of all trends and patterns regarding resonance in string instruments and resonance in wind instruments.

Evidence for Scoring: Group might observe that length seems to play a role in determining the resonant frequencies in both kinds of instruments, but, at least for string instruments, the tension and weight of the strings also seem to matter. Group might observe that placing extra mass (say, a piece of tape) on a guitar string will lower its resonant frequency, or that, as any string undergoes an increase in tension or a shortening of length, its resonant frequencies increase.

3. Gather evidence to support arguments, findings, or lines of reasoning.

College Ready Description: Group adequately evaluates evidence for quality and quantity.

Evidence for Scoring: In surveying musical instrument designs, the group may observe (and thus model the design after) the common elements found in real, working instruments such as the relationship between the length of the strings or tubes and their characteristic (resonant) pitches. In the process, the group may distinguish between more complex wind instrument designs and those more closely aligned with the single tube being modeled by simple longitudinal spring resonance.

4. Support or modify claims based on the results of inquiry.

College Ready Description: Group refines original thinking and adjusts arrangements of elements based on thoughtful examination of properties, accurate graphing, and careful observations of trends and patterns.

Evidence for Scoring: Group might suppose that the increase in a string's or spring's resonant frequencies is directly proportional to the increase in tension placed on the spring or string, but after close analysis, the group might later conclude that this is not a linear (directly proportional) relationship.

C. Problem Solving**2. Develop and apply multiple strategies to solve problems.**

College Ready Description: Group uses an adequate range of appropriate methods, devices, techniques, and strategies to test for factors affecting the resonant frequencies of a string or a spring.

Evidence for Scoring: Group's techniques might include a test varying only the length of the string/spring (using a range of vibration settings for each selected length to find the resonant frequencies for that length).

3. Collect evidence and data systematically and directly relate to solving a problem.

College Ready Description: Group systematically collects adequate experimental data related to refining and finalizing the mathematical model of resonance in transversely and longitudinally vibrating systems.

Evidence for Scoring: Group may conduct tests of the effects of length alone (using a range of vibration settings for each selected length to find the resonant frequencies for that length), keeping the tension and string/spring weight constant. After that data is tabulated, another group might conduct similar tests, controlling for length and weight, but varying tension.

D. Academic Behaviors**3. Strive for accuracy and precision.**

College Ready Description: Group carefully and correctly collects and reports experimental data throughout all stages of planning and execution.

Evidence for Scoring: Group includes all trial runs of the tension variation tests, even those that were subsequently deemed as outliers and not used in the final curve fitting.

4. Persevere to complete and master tasks.

College Ready Description: Group prepares and delivers a presentation that reflects thorough understanding of each element of the task and meets all requirements of the assignment.

Evidence for Scoring: Group's presentation does not only tabulate, graph, and curve fit the three analyses for each type of resonating system, it also documents the preliminary research and decision making that led to the tests thus conducted. Group's post-analysis discussion should also address how the longitudinally resonating spring is a direct analogy of how air itself resonates in the tube of a wind instrument.

E. Work Habits

2. Work collaboratively.

College Ready Description: Group includes and involves all members, who actively and effectively contribute to group discussion regarding the relevance of various factors to the resonant frequencies produced by musical instruments or who actively and effectively contribute to the design of experiments that can reveal the mathematical relationships of these factors to the frequencies they produce.

Evidence for Scoring: A student might make relevant comments and offer constructive suggestions or questions as the group works to determine the factors to be investigated, the order of tasks needed, the individual roles, and the design/execution of the experiments themselves.

F. Academic Integrity

3. Include the ideas of others and the complexities of the debate, issue, or problem.

College Ready Description: Group is able to evaluate and incorporate, if appropriate, the contributions of members to generate a more complete and coherent explanation to address the problem at hand.

Evidence for Scoring: When members share ideas after brainstorming, group actively engages with suggestions and attempts to incorporate them into a series of experiments to perform.

FOUNDATIONAL SKILLS

B. Writing Across the Curriculum

1. Write clearly and coherently using standard writing conventions.

College Ready Description: Group uses relevant diagrams, graphs, and text to clearly communicate ideas. Group uses line graphs to show the sorts of mathematical relationships that data analysis would reveal analytically.

Evidence for Scoring: Group uses both components in the presentation to best communicate the findings.

C. Research Across the Curriculum

5. Synthesize and organize information effectively.

College Ready Description: Group effectively sequences the presentation of experimental data to support the final conclusion(s).

Evidence for Scoring: Group reports data for each of the factors investigated separately (along with their graph) prior to presentation of the regression implying the mathematical model, so that the audience members would almost surmise the model from the shape of the graph. The regression result would seem eminently plausible—almost necessary—when then derived.

6. Design and present an effective product.

College Ready Description: Group determines an effective order for presenting major and minor features of the experiment and its results.

Evidence for Scoring: Group's presentation starts with a justification as to why the factors investigated were identified in the first place, followed by descriptions of the experiments and summary graphs, regression results, and basic mathematical models drawn as conclusions. Group saves minor issues such

as further ideas for more trials or experiments, other factors needing investigating, etc., for the final discussion.

8. Present final product.

College Ready Description: Group presents the experiment and results in a clear, concise, and coherent manner.

Evidence for Scoring: During the presentation, group engages the audience with spoken narrative and visual elements that complement one another. The audience does not struggle to identify and interpret the central claim and supporting arguments made by the group.

D. Use of Data

1. Identify patterns or departures from patterns among data.

College Ready Description: Group adequately identifies relevant trends in the graphs as well as patterns in the instruments studied in the preliminary research.

Evidence for Scoring: Group may note that guitar strings producing lower resonant pitches tend to be both looser and thicker (heavier) than strings producing higher resonant pitches, and the group may then observe in the experimental data that lower tension and higher linear mass density each (separately) lower the resulting resonant frequencies.

2. Use statistical and probabilistic skills necessary for planning an investigation, and collecting, analyzing, and interpreting data.

College Ready Description: Group uses appropriate best fit regression techniques and data ranges to quantify the relationships indicated in the resonance data.

Evidence for Scoring: Group's regression may not reveal much in the first couple of trials (i.e., all may appear proportional or inversely proportional), but when the factor being studied is varied widely enough, the mathematical dependency becomes clearer.

3. Present analyzed data and communicate finding in a variety of formats.

College Ready Description: Group delivers a presentation that adequately details experimental research to determine some factors affecting resonance in strings and springs.

Evidence for Scoring: Group's presentation specifies which factor was being varied (and which others controlled), the degree of precision, the number of trials, and any outliers discarded. Group uses appropriate visuals and experimental results to clearly convey findings in a report written for a specified audience. Group graphs data showing each factor's independent effect on resonance frequencies for best visual summary then analyzes for best fit curve as the best mathematical summary.

E. Technology

1. Use technology to gather information.

College Ready Description: Group uses appropriate devices to accurately measure physical properties.

Evidence for Scoring: Group's tension analysis uses a varying amount of weight on a pulley to create a known source of constant tension and the electronic vibration generator to create a known source of steady frequency.

2. Use technology to organize, manage and analyze information.

College Ready Description: Group utilizes technology to analyze the experimental data.

Evidence for Scoring: Group might use a spreadsheet to both graph each factor's data and perform regression to determine the mathematical model best fitting that data.

4. Use technology appropriately.

College Ready Description: Group identifies when technology may not be necessary or appropriate to communicate findings.

Evidence for Scoring: Group makes a careful hand drawing of each apparatus used in the Investigating trials, with all dimensions/aspects labeled clearly and consistently but uses a spreadsheet to present the graphical and analytical results/conclusions and uses a word processor for the report/discussion itself.

Good Vibrations: Music Resounds with Physics! – Scoring Instructions

There are two scoring sheets for this CRA: one for individual work and one for group work. Use either or both as desired for your class.

Place a score (1-4) in each row of the scoring sheet corresponding to the student's college readiness level.

Exceeding College Ready (4): Substantially exceeds the performance expectations

College Ready (3): Shows proficiency in all of the performance expectations

Approaching College Ready (2): Meets only some of the performance expectations

Initiating College Ready (1): Does not yet meet the performance expectations

Suggested Grade Conversion:

This chart reflects equal weight given to each skill. As key cognitive skills, foundational skills, and discipline content knowledge are all important elements of college readiness, we recommend this grading approach. However, you may certainly choose to implement different weights to particular scales and assign a grade at your discretion.

Individual Work:

Score	Grade		Score	Grade		Score	Grade		Score	Grade
56	100		45	89		34	78.5		23	72
55	99.5		44	88		33	78		22	71
54	99		43	87		32	77.5		21	70
53	98.5		42	86		31	77		20	68
52	98		41	85		30	76.5		19	66
51	97		40	84		29	76		18	64
50	96		39	83		28	75		17	62
49	95		38	82		27	74.5		16	60
48	94		37	81		26	74			
47	92		36	80		25	73.5			
46	90		35	79		24	73			

Group Work:

Score	Grade		Score	Grade		Score	Grade		Score	Grade
36	100		28	87		20	77		12	68
35	99		27	85		19	76		11	66
34	98		26	84		18	75		10	64
33	96.5		25	83		17	74		9	62
32	95		24	81.5		16	73		8	60
31	93		23	80		15	72			
30	91		22	79		14	71			
29	89		21	78		13	70			