CURRICULUM GUIDE FOR

Physics of Sound

(Based on the FOSS Physics of Sound Science Kit)

Wallingford Public Schools
Third Grade
Science

Approved by Science Management Team October 3, 2006
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UNIT SUMMARY

Through hands-on investigations students will understand how sound is generated and how sounds can be made louder and softer (loudness) and higher and lower (pitch). They will also investigate how sound travels through a variety of materials, and how sound is reflected and/or absorbed by different materials. Students will also understand the structure and function of the ear.

STAGE 1- STANDARDS/GOALS

What should students understand, know, and be able to do? Stage one identifies the desired results of the unit including the related state science content standards and expected performances, enduring understandings, essential questions, knowledge and skills.

Enduring Understandings *Insights earned from exploring generalizations via the essential questions (Students will understand THAT…) K-12 enduring understandings are those understandings that should be developed over time, they are not expected to be mastered over one unit or one year.*	**Essential Questions** *Inquiry used to explore generalizations*
<u>*Overarching Enduring Understandings:*</u> • Science is the method of observation and investigation used to understand our world. (K-12) • Inquiry is the integration of process skills, the application of scientific content, and critical thinking to solve problems. (K-12) <u>*Unit Specific Enduring Understandings:*</u> • Energy is motion (movement). • Sound is a form of energy. • Sound is energy that is produced by vibrating objects. (The only way sound is created is through vibration.) • Sound can be described by pitch (frequency) and volume and other aspects. • Sound energy (form of kinetic energy) is transmitted through different materials and the air. • Sound is reflected and/or absorbed by different materials. The nature of materials that sound travels through affects the transmission and absorption of sound.	• How is inquiry used to investigate the answers to questions we pose? • What is sound? • How is sound produced? • How does sound travel? • How does sound interact in our environment? • How is energy transformed into sound? • How do humans perceive (‘hear’) sound? • How do you describe differences in sound? • What materials and variables affect how you hear sound? • How does the shape of an object (shape of room, dome, microphone, speaker etc.) impact hearing?

• The structure of the human ear and sound devices can enhance the quality of hearing.	

Knowledge and Skills

What students are expected to know and be able to do

The knowledge and skills in this section have been extracted from Wallingford's K-5 Science Scope and Sequence.

Knowledge

K1. Describe the factors that affect the **pitch** and **loudness** of sound produced by vibrating objects.

- Pitch (frequency) is the lowness or highness of a sound, also know as musical note.
- Vibration is to move back and forth (or up and down).
- Changing the length, width, tension, or thickness of an object affects the pitch of the sound when it vibrates. Longer, thicker, wider items usually produce a lower pitch. Shorter smaller items usually produce a higher pitch.
- Volume is the loudness of a sound. Changing the amount of vibration affects the loudness. More vibration (more energy) is louder. .

K2. Produce sounds with different pitches and volume levels.

K3. Describe how sound is transmitted, reflected and/or absorbed by different materials.

- Some materials absorb sound and some materials reflect sound. Smaller, softer, more irregular materials absorb sound better. Harder, more regular, and larger objects reflect sound better.
- Sound can be reflected and heard as an echo.
- Sound travels differently through solids, liquids and gases. (fastest in solids and slowest in air).

K4. Demonstrate how sound is affected by different materials (air, water, foam etc.) in different environments. (large room, small room, room with dome etc.)

K5. Describe the structure and function of the human ear.

K6. Explain how humans perceive sound including how the ear functions and how the nervous system sends messages to the brain (receptors).

- Explore appropriate decibel levels of common sounds and justify reasons for having sounds at different decibels.
- Explore technological applications of sound. (hearing aids, microphones, speakers, megaphones)

K7. Explore decibel levels of common sounds and explain reasons why sounds are different decibel levels.

K9. Explore technological applications related to sound. (hearing aids, microphones, speakers, megaphones)

Skills

S1. Generate investigable and non-investigable questions.

S2. Observe objects and describe commonalities and differences among them.

S3. Classify, based on observations of properties.

S4. Predict what might happen.

S5. Design an investigation to help answer an investigable question.

S6. Conduct simple investigations.

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S7. Collect and record data utilizing simple equipment and measuring tools.
S8. Organize results in an appropriate manner, using:
- Graphic organizers, charts and graphs, illustrations or diagrams, simple reports, etc.

S9. Communicate results or information in an appropriate manner, using:
- Presentation, visuals, simple reports, etc.

Content Standard(s) *Generalizations about what students should know and be able to do.*	
CSDE Content Standards (CSDE Science Framework 2004)	**CSDE Primary Expected Performances** (CSDE Science Framework 2004)
Energy Transfer and Transformations – What is the role of energy in our world? **5.1 - Sound and light are forms of energy.** ♦ Sound is a form of energy that is produced by the vibration of objects and is transmitted by the vibration of air and objects. *Structure and Function – How are organisms structured to ensure efficiency and survival?* **5.2 - Perceiving and responding to information about the environment is critical to the survival of organisms.** The sense organs perceive stimuli from the environment and send signals to the brain through the nervous system.	B17. Describe the factors that affect the pitch and loudness of sound produced by vibrating objects. B18. Describe how sound is transmitted, reflected and/or absorbed by different materials. B21. Describe the structure and function of the human senses and the signals they perceive. (ear for sound)
Scientific Inquiry	B INQ.1 Make observations and ask questions about objects, organisms and the environment. B INQ.2 Seek relevant information in books, magazines and electronic media. B INQ.3 Design and conduct simple investigations. B INQ.4 Employ simple equipment and measuring tools to gather data and extend the senses.

Scientific Literacy	B INQ.5 Use data to construct reasonable explanations. B INQ.6 Analyze, critique and communicate investigations using words, graphs and drawings. B INQ.7 Read and write a variety of science-related fiction and nonfiction texts.
Scientific Numeracy	B INQ.8 Search the Web and locate relevant science information. B INQ.9 Use measurement tools and standard units (e.g., cm, m, g, kg) to describe objects and materials. B INQ.10 Use mathematics to analyze, interpret and present data.

STAGE 2 – DETERMINE ACCEPTABLE EVIDENCE

How will we know if students have achieved the desired results and met the content standards? How will we know that students really understand? Stage two identifies the acceptable evidence that students have acquired the understandings, knowledge, and skills identified in stage one.

Performance Task(s) *Authentic application in new context to evaluate student achievement of desired results designed according to GRASPS. (Goal, Role, Audience, Setting Performance, Standards)*	**Other Evidence** *Other methods to evaluate student achievement of desired results.*

• The Hollywood game show, "Name That Tune", is coming to our school. On Friday our class will present original instruments in which they will play a "tune" that must be easily recognized by the audience.
  o Your goal is to create an instrument that will demonstrate your understanding of pitch and volume.
  o Your role is to play a song on your instrument that can be guessed by the audience. You will need to play your song two times, first softly and then loudly the second time. You will also need to explain how you developed your instrument.
  o You will document the development and revisions made to your instrument in your science notebook. You will write about what problems you encountered along the way, how you solved these problems and how you manipulated the instrument to create your melody at different volumes.
• Write a letter to your favorite drummer in a rock band explaining the eardrum and why he/she should wear headphones while playing.
• Create a musical instrument at home from assorted materials (rubber balloons, elastics, glass bottles, etc.). Demonstrate or explain how to use the instrument to vary the pitch and loudness.
• Create a bedroom that will allow you to play an instrument as loud as you want! You will design a sound proof bedroom in your house using different types of materials, shape of the room and the position of your instrument. Include reasons for your choice of materials and communicate how your room will be successful.
	• See teacher guide "Assessment" section for sample rubrics, writing prompts and portfolio ideas.
	• Assess process skills such as raising questions, developing a plan, collecting and organizing observations, and drawing conclusions.
	• Use the essential questions as writing prompts

STAGE 3 – LESSON ACTIVITIES

What will need to be taught and coached, and how should it best be taught, in light of the performance goals in stage one? How will we make learning both engaging and effective, given the goals (stage 1) and needed evidence (stage 2)? Stage 3 helps teachers plan learning experiences that align with stage one and enables students to be successful in stage two. Lesson activities are suggested, however, teachers are encouraged to customize these activities, maintaining alignment with stages one and two.

The suggested lesson activities are not sequenced in any particular order. Teachers may select which lesson activities will best meet the needs of their students and the unit objectives. Each lesson activity is coded with the corresponding knowledge (K) and/or skill (S) objectives that are found in stage one.

In addition to the lessons found in the teacher guide:

What Makes Sound?

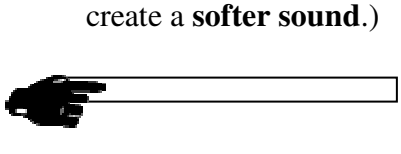
Provide students with a balloon, elastic and ruler (plastic or wood ruler). Pose the question:

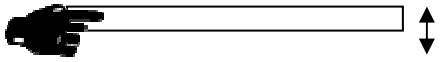
- *How many ways can your group make sound*? (share ideas after students explore for 10-15 minutes)
- *What do all these have in common? What causes sound?* (Students should be able to identify that they all the situations have movement / vibration. They should conclude that when they see something vibrating they hear sound.)
- *Challenge – Can they use those materials to play Twinkle, Twinkle Little Star?* (they need to vary the pitch)

Exploring the sound you can make with your ruler

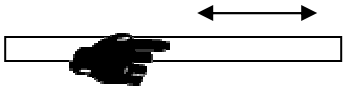
Have students use the ruler to produce a sound that is loud and one that is soft. They can do this by holding a few centimeters on the edge of their desk and pushing up or down on the other end to cause it to vibrate. Pose the question:

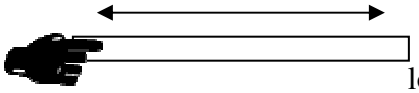
- *Can you use the ruler to make a loud sound and a soft sound?* (Students should discover that they should hold the ruler in the same place each time. They should discover that when the ruler is pulled up or pushed down a **large distance** there is a **louder sound**. They should also discover that when the end of the ruler is pushed up or down lightly (**small distance**) they will create a **softer sound**.)


Loud sound


soft sound

- *Can you use the ruler to make a high pitch and a lower pitch?* (Students should discover that they will need change where they hold the ruler to do this. The amount of vibration is related to loudness. A shorter distance that is vibrating is higher the pitch - longer the distance of the ruler that is vibrating the lower the pitch.)


higher pitch


lower pitch

Related Questions:

1. How does the "rate" at which the ruler vibrates change as you change the length of the ruler?
2. Compare the musical notes that the ruler makes when it is plunked at two different positions.
3. How does the length of ruler that is vibrating seem to relate to the pitch of the note that is made when it is "plunked"?
4. What seems to make the sound louder?

Meet with your music teachers to review the objectives and discuss how he/she can assist with the unit.

Use a guitar to investigate:

- How the thickness of a string affects the pitch? (thicker string has a lower pitch)
- How the tension of a string affects the pitch? (less tension is lower pitch)

Use a xylophone and other instruments such as a trombone to see how you can change the pitch and loudness. Have students explain and/or diagram their reasoning.

Fill 4-5 glass containers (cups, bottles, etc,) with different amounts of water. What causes the

different pitches?

- NOTE: Students need to discover that it is the **amount of air**, not the amount of water in a container that is vibrating. The more air that is vibrating, the lower the pitch
- NOTE: Ensure that all the containers are the same kind.

Use the literature books to explore the structure and function of the human ear. Have students identify the basic parts including the outer ear, inner ear, middle ear, ear drum, and the auditory nerve. Students should be able to identify each part mentioned above and describe the function(s) of each part.

Senses Resource Web Sites.

www.sedl.org/scimath/pasopartners/senses/lesson6.html#explore

http://sln.fi.edu/qa97/me12/me12.html

http://www.iit.edu/~smile/bi9705.html

www.iit.edu/~smile/bi9704.html

www.iit.edu/~smile/biolinde.html

www.ktca.org/newtons/11/tstesmll.html

http://faculty.washington.edu/chudler/bigear.html (great site!)

Guide for
SOUND LITERATURE
Inquiry Investigation
Grade 3

Approximate Time – 4 lessons

Related State Content Standard(s):	Related State Expected Performance(s):
Scientific literacy includes speaking, listening, presenting, interpreting, reading and writing about science. Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media. *Energy Transfer and Transformations – What is the role of energy in our world?* **5.1 Sound and light are forms of energy.** • Sound is a form of energy that is produced by the vibration of objects and is transmitted by the vibration of air and objects. **5.2-Perceiving and responding to information about the environment is critical to the survival of organisms.** • The sense organs perceive stimuli from the environment and send signals to the brain through the nervous system.	Read and write a variety of science-related fiction and nonfiction texts. Seek relevant information in books, magazines, and electronic media. Analyze, critique and communicate investigations using words, graphs, and drawings. B 17. Describe the factors that affect the pitch and loudness of sound produced by vibrating objects. B18. Describe how sound is transmitted, reflected and/or absorbed by different materials. B21. Describe the structure and function of the human senses and the signals they perceive. (ear for sound)
Related Enduring Understanding(s):	Related Essential Question(s):
** See page 3	• How is inquiry used to investigate the answers to questions we pose? • What is sound? • How is sound produced? • How does sound travel? • How does sound interact in our environment? • How is energy transformed into sound? • How do humans perceive ('hear') sound? • How do you describe differences in sound? • What materials and variables affect how you hear sound?

Physics of Sound

	• How does the shape of an object (shape of room, dome, microphone, speaker etc.) impact hearing?
What simple **content objectives**/goals do you want to accomplish with this investigation? (see district curriculum documents)	What simple **process skills** do you want to improve with this investigation?
Possibly all objectives – see page 4 for a list	Questioning Drawing Conclusions Communication Developing Interpretation

What phase of this investigation will you provide the most modeling/templates/mini-lessons/scaffolding for better skill development?

Model using FQR for phase one on how to develop questions from text.
Model planning for literature investigations prior to phase three.

Materials/Resources:

**Non-fiction books related to the topics such as sound, hearing, and the ear – at various reading levels and content related to the content objectives.

Note – Teachers should contact their Library Media specialist to acquire the necessary books, at a variety of levels, for use in their classroom during this unit. Literature books have been purchased to support the science kits.

OPTIONAL – materials for students to conduct mini-investigations related to investigation questions such as:

Tuning forks	String	spoons	Geoboards boards
Water and pitcher	Paper clips	Wood dowels	Balloons
Cloth, foam…various materials	Glass jars or cups	Various elastics	Rulers

What kinds of investigations do you anticipate students designing?

- How do you change pitch?
- How do you change the volume?
- How materials affect sound?
- How does an ear works and other devices that receives sound?
- Which materials absorb sound the best?
- Which materials reflect sound the best?
- How does sound travel through different things?
- I wonder how string instruments work?
- Does loud noise really damage our ears? Why?
- What are the parts of the ear and how do we hear sounds?

PHASE 1 – Observing and Questioning

INQUIRY STARTERS

- What is the launching activity or **inquiry starter** for the investigation?
- What will be your **inquiry starter prompt**? How will you "invite" your audience to work with the materials?
- What **materials** will you use for the inquiry starters?
- How will you **elicit and collect or display student's questions**? Will they share questions orally? In writing?
- **Choosing investigation questions**: How will you help your students determine which questions they can choose from to investigate? How will you or the students form investigation groups?

Materials	Task	Hints
sticky notes, FQR chart markers nonfiction books	Setting the context – Begin session by doing a book talk with the students, highlighting the different types and levels of books that the students will be looking at. Teacher model Fact, Question, Response (FQR) using a related text. Model how to use FQR to develop question on which to further investigate. You may want to use the book, *Sound* by Delta Science Readers to model your thoughts. See page 26 for sample FQR template.	Use books from the library for the book talk Preview books and eliminate any books that do not match your content objectives Preview one or two books more closely and complete some sticky notes with facts, questions, and reactions. This will help you prepare for the modeling of the FQR. Use a 'think aloud' letting all thoughts be explicit for students while reading a sample text. You may also need to do a guided practice with the class or a small group to further assist students with the FQR chart. You may want to copy the same passage for all students and use this passage for guided practice. Consider how you may want to differentiate for diverse learners.
books	**Inquiry starter** -Have students explore the non-fiction books, using FQR. Teacher should encourage students to record observations, questions, and reactions. This can be done in their notebook or on post-it notes to be placed on a class chart.	**Assessment note:** This is an opportunity for the teacher to formatively assess the ability of your students to discriminate between fact and opinion, the ability to formulate a question, and personally respond to new information.

	Have students share questions raised and chart questions. Teacher may choose the most appropriate questions for investigation based on the content objectives.	You may want to organize or group the questions according to objective topics and/or remove questions that are not related to the content objectives.
Posted questions	Teacher can create groups for planning and investigating, (groups of 2-3 are recommended). Things to consider: How will you help your students determine which questions they can choose from to investigate? How will you or students form investigation groups? Gallery walk - have participants read through the questions and chose one that interests them.	The teacher may want to form groups based on student interest in a particular question. Assigning group roles such as materials manager, recorder, communicator, etc. may be helpful. Keep an eye out for anyone having a difficult time finding partners and help them connect with a group. Split groups that are larger than 3. Tell participants that they are not locked into the question that they choose. They can change the question along the way.

PHASE 2 – Planning and Investigating

INVESTINGATION

- What **additional materials** will you introduce? How will you introduce additional materials participants can use to study the phenomena?
- How will you manage/organize materials, set up and clean up?
- How will you support the groups in **planning** their investigation? Will you provide criteria or planning sheets?
- How will you facilitate during the investigation?

Time/Materials	Task	Hints
chart markers questions	Model how to plan an investigation that includes literature. (using key words, table of contents, headings, bold words, and index, title and cover picture, use of more than one resource to confirm findings, etc.). See page 27 for sample planning template	Model a question that relies heavily on the literature for this planning - model using a 'think aloud'. Have students consider: "What key words will I use?" "What books will I use?" "How will I select the books I should use?"

	for a literature inquiry.	
	Teacher directs each group to develop a plan to use to investigate their question. This should be recorded by each group to share with the class in words or pictures.	Consider how you may want to differentiate for diverse learners.
Science notebooks Non-fiction books	Conduct Investigation "You will have approximately XX minutes to: carry out your investigations, ask further questions, talk to each other about your observations and ideas, propose explanations, and record your observations and explanations using charts, diagrams, and through writing."	Remind them to record data / findings in their notebook. Ask questions to determine what and how the groups are doing and plan for assistance that may be needed by different groups. Facilitate toward content objectives.
chart paper markers	Finish investigation and start preparing for presentation. Discuss expectations during presentation such as visual, time, contents, etc.	Give participants a 10 minute warning. Partial clean up-some groups may want to use materials during their presentation. If groups finish early, have groups pair share their presentations. It helps everyone to put their understanding into words thereby strengthening that understanding. It also allows for "rehearsal" before the whole group sharing. Encourage students to keep the presentation simple – the sharing of learning is more important than having a "pretty" visual.

PHASE 3 – Interpreting Results and Communicating

SHARING RESULTS AND PROCESSING FOR MEANING

- How will investigation groups present what they have learned from their investigations? (visual, oral presentation, combination, etc.) How will you decide the order of the presentations? (by similar questions, content goals, random, etc.)
- How will the facilitator synthesize the knowledge and findings of the participants for the group?

Time/Materials	Task	Hints
timer	Presentations (2-3 minutes per group) and synthesis of findings and content	Use a timer to keep groups under the allotted time.

tape or push pins		Consider how you may need to differentiate for diverse learners.
	Tell the group that this inquiry was designed with some conceptual ideas in mind that could be reached through investigation. The hope was that most of the ideas would be reached by some people, and that by sharing, these ideas would be communicated to everyone. Summarize the conceptual ideas that were uncovered during this literature investigation. Refer back to the content objectives on page 4. Have students write a reflection in their science notebook after the teacher summary.	Design follow up lessons that reinforce the concepts and skills learned during this inquiry. Or lessons may need to address content and/or skills that were not addressed during this inquiry.

Guide for
HANDS-ON SOUND
Inquiry Investigation
GRADE 3

This material, developed by the CT Center for Science Inquiry Teaching and Learning, is based upon work supported by the Connecticut State Department of Higher Education through the U.S. State Department of Education Teacher Quality State Grant Program, under PL 107-110, Title II, Part A, Subpart 3,CDHE# 12060;Agency #DHE66500-20107;Identification #05DHE1028GR.
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Modified by Wallingford Public Schools

This guide is a tool for helping you plan an inquiry activity. The prime factor is that your students get the opportunity to practice choosing their own question and planning and carrying out an investigation to find out what they can learn from investigating that question.

Approx. Time: 5 periods

Related State Content Standard(s):	Related State Expected Performance(s):
Energy Transfer and Transformations – What is the role of energy in our world? **5.1 Sound and light are forms of energy.** • Sound is a form of energy that is produced by the vibration of objects and is transmitted by the vibration of air and objects. **5.2-Perceiving and responding to information about the environment is critical to the survival of organisms.** • The sense organs perceive stimuli from the environment and send signals to the brain through the nervous system.	B17. Describe the factors that affect the pitch and loudness of sound produced by vibrating objects. B18. Describe how sound is transmitted, reflected and/or absorbed by different materials. B21. Describe the structure and function of the human senses and the signals they perceive. (ear)
Related Enduring Understanding(s):	**Related Essential Question(s):**
** See enduring understandings on page 3.	How is inquiry used to investigate the answers to questions we pose? What is sound? How is sound produced?

	How does sound travel? How does sound interact in our environment? How is energy transformed into sound? How do you describe differences in sound? What materials and variables affect how you hear sound? How does the shape of an object (shape of room, dome, microphone, speaker etc.) impact hearing?
What simple **content objectives**/goals do you want to accomplish with this investigation? (see district curriculum documents)	What simple **process skills** do you want to improve with this investigation?
K1. Describe the factors that affect the pitch and loudness of sound produced by vibrating objects. o Changing the length, width, tension, or thickness of an object affects the pitch of the sound when it vibrates. o Changing the amount of vibration affects the loudness. More vibration (more energy) is louder. K2. Produce sounds with different pitches and volume levels. K3. Describe how sound is transmitted, reflected and/or absorbed by different materials. o Some materials absorb sound and some materials reflect sound. Smaller, softer, more irregular materials absorb sound better. Harder, more regular, and larger objects reflect sound better. o Sound can be reflected and heard as an echo. o Sound travels differently through solids, liquids and gases. (fastest in solids and slowest in air). K4. Demonstrate how sound is affected by different materials (air, water, foam etc.)	• Observation • Planning • Generate testable and research questions • Predict • Design a fair test to answer an testable (investigable) question. • Conduct a simple investigation • Revise a plan based on observation/results. • Prediction • Organize and collect data • Communicate findings

in different environments. (large room, small room, room with dome etc.)	

What phase of this investigation will you provide the most modeling/templates/mini-lessons/scaffolding for better skill development?

Model question and help students create questions
Determine testable and research questions.

Materials/Resources:

Assorted materials from Physics of Sound kit

Additional materials such as:

Tuning forks	Paper cups	String	Glass jars or cups
Water and pitcher	Paper clips	Geo-boards	Spoons
Nails	Peg boards	Various elastics	Balloons
Cloth, foam…various materials	Assorted simple instruments	Pencils (to use as a "drum" stick)	Rulers (plastic and/or wood)
Balloons	Plastic straws		

What kinds of investigations do you anticipate students designing?

Sample student investigation questions:

- How does the amount of water affect the sound?
- How does the material use to tap affect the sound?
- Does the shape of the container affect the sound and why?
- How do different liquids or different materials affect the sound?
- How do different materials affect sound?
- Do drums made of different materials sound differently even if they are the same size?
- How/Why does the amount of water in a glass affect the sound when the glass is hit with a stick?

PHASE 1 – Observing and Questioning

INQUIRY STARTERS

- Begin by taping a glass with a nail, then add water as you are taping.
- What will be your **inquiry starter prompt**? How will you "invite" your audience to work with the materials?
- four glass beakers, water, pencil, nails, plastic straws

Task	Hints
Introduce students to this sound inquiry by explaining that they will be exploring concepts related to sound using different materials. Have students explore different materials such as glass containers w/ different amounts of water, pencils, straws, balloons, rulers, and elastics. Challenge them by saying, "How many different ways can you make sound? How can you change sound?" Create a T-chart on the board with "I notice…" and "I wonder…" Chart the student's observations (I notice) and questions (I wonder). See sample "I Notice… I Wonder" template on page 28 Have students share what they noticed and wondered as they "messed about" with the materials	Different materials can be used to raise questions. You may want to divide the materials into two or three different groups and have them explore different stations. **Assessment note:** This is an opportunity for the teacher to formatively assess the ability of your students to write detailed observations (I notice) and questions (questions).
Work with the class to sort the questions into investigable and non-investigable questions. Explain that investigable questions (testable questions) can be done in the "hear and now" with materials that can be	**Guided Lesson/Thinking Tool:** Try to help students rephrase their questions into investigable questions that can be investigated in the "here and now" with the materials that we have available. "XXXXXX" is a great question, but not investigable with our materials.

easily gathered. Non-investigable or (questions that are not testable) can be answered using books or reading about the answers. Non-investigable questions are often "why" questions.	See page 19 for some of the sample questions that students may generate Teacher may choose the most appropriate questions for investigation based on the content objectives of this lesson. Non-related questions may be removed from the group. Non-investigable questions can be saved for a literature inquiry.
Teacher forms investigation groups. (2-3 students per group)	The teacher may want to form groups based on student interest in a particular question. Things to consider: How will you help your students determine which questions they can choose from to investigate? How will you or students form investigation groups?
Have groups read the questions and chose one to investigate that interests them.	

PHASE 2 – Planning and Investigating

INVESTIGATION

- What **additional materials** will you introduce? How will you introduce additional materials participants can use to study the phenomena?
- How will you manage/organize materials, set up and clean up?
- How will you support the groups in **planning** their investigation? Will you provide criteria or planning sheets?
- How will you facilitate during the investigation?

Task	Hints
Once groups have selected their question for investigation, participants should generate a plan to investigate their question. The teacher may want to model a plan that includes: • Investigation Question • Materials	Assigning group roles such as materials manager, recorder, timer, etc. may be helpful. Teacher may choose to model a plan using a question that students are not investigating.

• My first step is… • My next step is… Class can brainstorm the elements of an effective plan while the teacher records on chart paper. This may include: ○ Question ○ Directions – numbered/sequenced steps ○ Revise plans when changes are made ○ List of materials w/ quantities ○ Jobs – if assigned ○ Must be reproducible (someone else should be able to duplicate the investigation and get same results ○ Labeled diagrams or drawings ○ Prediction / hypothesis ○ Type of results you will collect and how they might be	**Assessment Note:** This is an opportunity to formatively assess student planning.
Have students generate a plan to investigate their question. Their plan should include all of the important elements of the planning template. Each group member should have a plan recorded in their science notebook. Teachers may choose to use the "Investigation Plan Template" (page 29). This template can be taped into students' notebooks for future reference.	Explain that changes may need to be made to the plan during or after the investigation. Consider how you may differentiate for diverse learners. For example, some plans may include a lot of pictures or diagrams and less written directions. The plan can be done with minimal teacher input; in order for students to develop their own plans (mistakes are expected). Optional (if time allows): Students will pair share with another group. Each group member will record a positive comment and a comment for improvement on a "post-it" on author's plan. Comments could include: 1.I liked how you … 2.One improvement I would suggest is…

Using their investigation plans and materials, students can conduct their investigations. Model for student's appropriate use of materials. For example, what does the appropriate use of elastic bands look like? Students will record their observations during the investigation in their student notebooks. Teacher will facilitate with reminders to record observations. Removing students from their materials for a few minutes will help them concentrate on recording observations and noting revisions they made to their plan. If students finish their investigation early they can continue to investigate a related question or start preparing for their presentation/sharing with the larger group. Plan on ample time for clean-up procedures.	Materials can be distributed to each group by the teacher, or a designated student may gather them for his/her group. Plastic café trays may be helpful to manage the materials. Teacher should circulate, questioning and guiding groups. Remind students that a good plan may still need to be revised once you begin your investigation. **Guided Lesson/Thinking Tools**: Teacher may need to provide a mini-lesson on data collection and organization of this data. Some groups may need a template/chart to help with data collection.

Open Ended Questions and Comments to Help Guide Students During the Investigation

What do you know about…?
What will you need?
What will you add?
I wonder what will happen when…?
Why is that happening?
Show me how that…
How do you know that?
What do you see, notice, hear about…?
What does this do?
Where have you seen…?
What's happening with this?
What would you say about…?
How can we find out about…?
What other way can you try?
What else can you do about…?
What can you use this for?
Tell me about it.
What's your plan for that?
What does this remind you of?
Tell me more about…
How are you going to use…?
How will you use this today?
What does it need?
What else can you do about…?
What will happen if…?
How can we change that?
What happened when you did that?
What is different about that?
What will you do to change that?
Show me…
I'm noticing that…, how did that happen?

PHASE 3 – Interpreting Results and Communicating

SHARING RESULTS AND PROCESSING FOR MEANING

- How will investigation groups present what they have learned from their investigations? (visual, oral presentation, combination, etc.) How will you decide the order of the presentations? (by similar questions, content goals, random, etc.)
- How will the facilitator synthesize the knowledge and findings of the participants for the group?

Task	Hints
Discuss with students what would be in an "effective presentation" (such as: question, hypothesis/prediction, overview of procedure, results, and conclusion). Prepare to share results.	**Guided Lesson/Thinking Tool:** Teachers may find it helpful to take notes as students present; documenting which groups had evidence of each big idea. Teachers may choose to use the template, called "Preparing to Share Results," to prepare for sharing on page 30. Things to consider: How will students visually share their results? (overheads, chart paper, poster, etc.)
Student presentations Teacher will allow an allotted time for each group to share their results (approx 3 minutes).	Consider charting "findings/ conclusions" after each group presentation. This will be helpful later during the synthesis.

Sample Student Visual for Presentation:

Question: How does the type of liquid affect the sound?
Plan: We will use different liquids in each beaker (the same amount). In the beaker we had orange juice, water, coffee and tea. We will then tap each beaker and observe the different sounds that are created.

Hypothesis: We predicted the orange juice would have a higher pitch because it was thicker.

Results (data):
We found that the orange juice had a higher pitch because of the molecules that were close together in the beaker.

Conclusion:
Sound travels faster through denser materials. When sound travels faster it creates a higher pitch.

Synthesis – What have we learned about …….? Use specific examples from the class to support new learning/findings. Provide a copy (or have students copy into their notebook) of the big ideas/summary of investigation findings.	Use the big ideas (see below) to question students to guide them toward the content goals of the inquiry investigation.

Sample – Big Ideas/Summary of Investigation Findings:

- Sound is energy that is produced by vibrating objects. (The only way sound is created is through vibration.)
- Sound can be described by pitch and volume.
    a. Pitch is the lowness or highness of a sound also known as musical note.
    b. Frequency is the rate of vibration (number of vibrations per unit of time)
    c. Changing the length, tension, or thickness of an object affects the frequency of vibrations.
    d. Loudness is directly related to the amount of transferred energy.
- Sound travels through different materials and the air.
- Some materials absorb sound.
- Some materials can reflect sound (echoes).
- Sound travels through solids, liquids and air.

Design follow up activities to reinforce the concepts and skills learned during the inquiry and/or address concepts and/or skills that were not addressed during the inquiry.	

Fact	Question	Response

Planning Your Investigation

Literature Inquiry

Question:

_____

_____

_____

Key Words:

_____

_____

_____

Books to Use:

_____

_____

_____

My Findings:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

I Notice… *(observations)*	I Wonder… *(questions)*

Investigation Plan Template

Hands-on Inquiry

Team member names:_____
_____

Our **question** is:_____
_____

Our **prediction** is:_____
_____

Materials we will use:_____
_____
_____

PLAN

First, we will_____
_____
_____
_____

Then we will_____
_____
_____
_____

Next we will_____
_____
_____
_____

Finally we will_____
_____
_____
_____

What **changes/revisions** did you make to your original plan?

_____
_____
_____

Preparing To Share Results

Question: _____

Prediction: _____

_____

Summary of what you did (plan) _____

_____

_____

_____

_____

We found out that (data or results)_____

_____

Conclusion (WHY?) _____

_____

_____

Space for illustration/diagram of investigation plan and/or results.

LITERATURE RESOURCES

These literature resources have been purchased to supplement the kit and are housed in each elementary school library.

Guided Reading Sets (6 copies in each school)

Experiments with Sound - A True Book, Salvatore Tocci
Sound, Delta Science Readers
Sounds all Around, Newbridge, Angela Shelf Medearis
Hearing Sounds - It's Science, Sally Hewitt
A World of Sound, Nancy Leber and Robin Bromley (Ranger Rick)
Loud Emily, Alexis O'Neill
Musicians of the Sun, Gerald McDermott

Read Aloud (1 copy per school)

Hearing, Sue Hurwitz
Sound - Make it Work, The Hands on Approach to Science
My Ears, Kathy Furgang
Ears, Robert James
Sound - Step by Step, Helana Ramsay
Hearing Sounds - Science For Fun, Gary Gibson
Hearing, True Book, Murphy
Hearing, Gordon

Other Resources that may be found in your Library

Poems go Clang! A Collection of Noisy Verse, Illustrated by Debi Gliori
City Sounds, Rebecca Emberley
Hearing in Living things - Senses (Heinemann) (part of 1st grade Senses kit)
Shhh…A Book About Hearing, Dana Meachen Rau
Sound and Light, Robert Snedden

Materials List

Physics of Sound – Grade 3

(Based on the FOSS Physics of Sound kit)

Revised March 2006

1	Teachers guide with FOSS safety poster
1	Curriculum guide
1	Teachers Preparation Video
15	Foss Science Stories student books
8	Drop chamber, tagboard
8	Drop chamber vision barriers, cardboard
16	Sets of drop objects, 8 per set
12	Listening tubes, tagboard
8	Megaphones, tagboard
100	Paper fasteners, #4
32	Plastic bags
1	Package of small beans for tone generator
2	Binder clips, medium
4	Wood blocks
1	Cord with bead
5	Paper cups
50	Plastic cups
8	Wood dowels
2	Pieces of fishing line
2	Foam pieces
2	Half-meter sticks
2	Kalimba bases
2	Sets of Kalimba steel springs, 5 per set
4	Mallets
1	Box of paper clips, Large
4	Ping-pong balls
100	Rubber bands #14
8	Stethoscopes
50	Sticks, craft
1	Ball of string
1	Tone generator with 9-V battery
100	Tongue depressors
2	Sets of tuning forks, 2 per set
2	Sets of xylophone tubes, 5 per set
1	Tape, measuring 100 cm
8	Dishpans
1 box	Alcohol wipes
25	8” Balloons
25	Assorted elastics
5 sheets	Latex coverings

Teacher Background Notes

These science content background notes were created for teacher use only. We anticipate that these notes provide you, the teacher, with some useful background as you facilitate inquiry activities for your students. These notes are not meant to be an overview of the unit, but as background information for you that go beyond the content of this particular unit. These notes should not be replicated for your students; however, you may share some of the content when appropriate for the developmental level of your students.

****Additional background information can be found in the teacher's guide.****

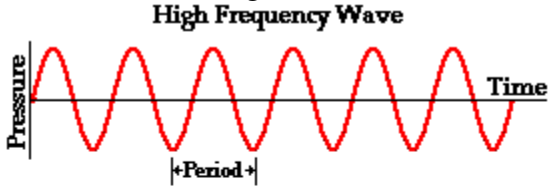
These notes have be prepared by Keith Gregorczyk.

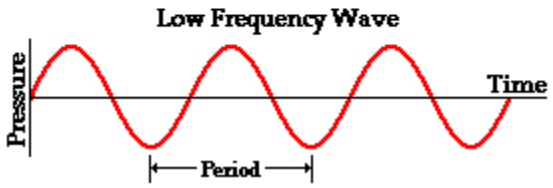
What is Sound?

Sound is considered a wave phenomenon. It is caused by vibrating objects which force the compression of surrounding material. These vibrations are very small, almost imperceptible. Sound can travel through a variety of mediums including solids. The speed of sound varies with the material it is traveling though. Sound moves slowest when traveling through a gas (like air), faster when traveling though a liquid (like water), and fastest when traveling though a solid (like a table). Sound moves at 750mph in air. Humans are most familiar with sound traveling through air.

What is a Wave?

In the simplest possible terms waves may be described by two numbers. The length between crests is called the period, and the height is called the amplitude. The height of a wave directly relates to the volume. The higher the wave the louder it is. The width of the wave directly relates to the pitch. The smaller the length between crests the higher the pitch will be.





Physics of Sound

Fig. 1. http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u11l2a.html

There are also two types of waves. The first is called a transverse wave. These are the type of waves one would expect to see at the ocean. The second type is called longitudinal or pressure wave. Sound is a pressure wave. Pressure waves are the repeated compression and rarefaction (rarefaction: a region of decreases density) of a medium caused by a vibrating object.

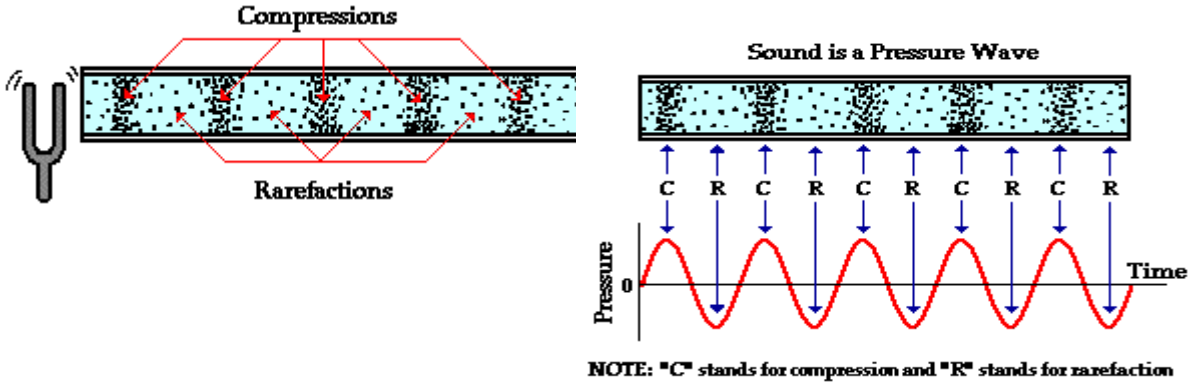


Fig. 2 and 3. http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u11l1c.html

How is sound transmitted?

Sound is produced by a vibrating object. Like a tuning fork, or vocal cords. Humans, most animals generally, produce sound biologically by vibrating vocal cords.

How is sound absorbed and reflected?

A reflection of sound is called an echo. How sound is reflected depends on the type and amount of surface it hits. This area of physics is called acoustics. More sound will be reflected from a smooth rigid surface, and less will be reflected from a soft irregular surface. A good example of this concept can be found in an auditorium. Behind the band it is advantageous to have smooth rigid surfaces that reflect the sound out into the audience. On the other hand if one wanted to sound proof a room they would want to pad the walls with a soft irregular surface, like ridged foam.

Sound is a form of Kinetic Energy.

Kinetic energy is the energy of motion. Anything that is moving has kinetic energy. When an object vibrates it has kinetic energy. The vibrating object forces air around it to compress and move away. The moving air then has kinetic energy because it is moving. The fact that sound has kinetic energy directly relates to why sound dissipates over a distance. The wave has to move through air, or whatever material it is traveling through, to do this it must displace (make vibrate) the molecules in the material. Making the molecules move requires energy. As

the wave travels and forces the molecules to move it slowly looses energy, and the wave starts to die.

How do we hear?

The human ear is an instrument capable of detecting fluctuations in pressure. It is broken up into three basic parts; the outer ear, the middle ear, and the inner ear. A medium must be in contact with the ear drum. The medium can be air or a liquid, preferably water. When the wave hits the ear drum it causes it to vibrate. The vibration travels through the various parts of the middle and is converted into electrical energy and sent to the brain via the auditory nerve. The design of the outer helps to trap sound and direct it toward the ear drum. This trapping is really just a reflection. By placing a cone over your ear you can increase the size of the earflap and therefore increase the amount of sound directed toward your ear drum. Modern devices increase your hearing ability by amplifying sound electronically. These systems are based on tiny microphones and speakers.

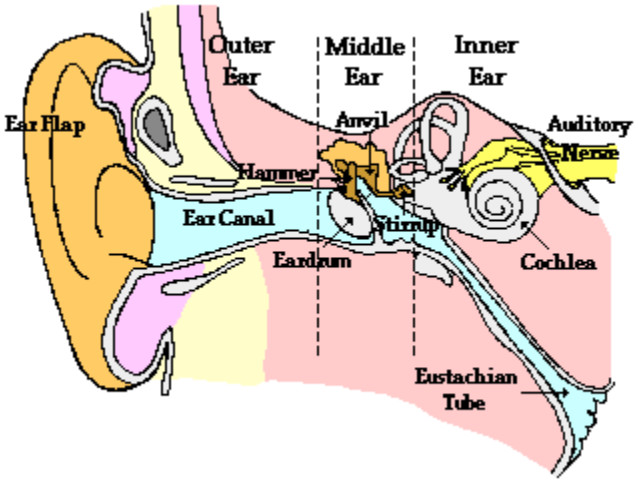


Fig 4. http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u11l2d.html

How do you measure sound?

Sound is measured by a variety of systems. The measurement system that concerns humans the most is called the decibel (db) system named in honor of Alexander Graham Bell. The decibel system is a logarithmic system. This means that 20db is not twice as loud as 10db. Zero decibels is called the threshold of hearing and 120 decibels is called the threshold of pain. An average conversation would be around 60 decibels and the rustle of leaves around 10 decibels.

How do I use a slinky to show waves?

A slinky is a great tool to illustrate how sound waves move. Stretch the slinky out by having a person hold each end. To show transverse waves (like at the ocean) simply wave the

slinky back and forth. This will produce a transverse wave. To produce a longitudinal wave (the type of wave sound produces), instead of waving your hand back and forth, push your hand forward, toward the person holding the other end of the slinky. This will produce a longitudinal wave. It should look like the slinky is compressing and then this compression is then moving to the other end of the slinky. Here is a diagram showing what a longitudinal wave on a slinky should look like.

Fig. 5.http://www.exo.net/~pauld/summer_institute/summer_day10waves/Slinky_in_hand.html

I N S T I T U T E · F O R · I N Q U I R Y
A DESCRIPTION OF INQUIRY

Appendix A

At the *Exploratorium Institute for Inquiry* our work in science education is deeply rooted in the belief that human beings are natural inquirers and that inquiry is at the heart of all learning. The work that we do with educators is designed to give them an opportunity to personally experience the process of learning science through inquiry. Our hope is that this experience will stimulate their thinking about how to create classrooms that are supportive environments for children's inquiry.

Inquiry is an approach to learning that involves a process of exploring the natural or material world, that leads to asking questions and making discoveries in the search for new understandings. Inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science.

The inquiry process is driven by one's own curiosity, wonder, interest or passion to understand an observation or solve a problem.

The process begins when the learner notices something that intrigues, surprises, or stimulates a question—something that is new, or something that may not make sense in relationship to the learner's previous experience or current understanding.

The next step is to take action—through continued observing, raising questions, making predictions, testing hypotheses and creating theories and conceptual models.

The learner must find her or his own pathway through this process. It is rarely a linear progression, but rather more of a back and forth, or cyclical, series of events.

As the process unfolds, more observations and questions emerge, giving occasion for deeper interaction and relationship with the phenomena—and greater potential for further development of understanding.

Along the way, the inquirer collects and records data, makes representations of results and explanations, and draws upon other resources such as books, videos and the expertise or insights of others.

Making meaning from the experience requires reflection, conversations and comparison of findings with others, interpretation of data and observations, and the application of new conceptions to other contexts. All of this serves to help the learner construct new mental frameworks of the world.

Teaching science using the inquiry process requires a fundamental reexamination of the relationship between the teacher and the learner whereby the teacher becomes a facilitator or guide for the learner's own process of discovery and creating understanding of the world.

Map of IFI Inquiry Structure

(3 Phases of Inquiry Diagram)

Appendix B