

Galileo: The Man of Disbelief

Grade Level or Special Area: 5th Grade

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Length of Unit: Eight lessons over the course of twelve days.

I. ABSTRACT

“I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forego their use.”--Galileo. Like scientists before us, have your students take chances and learn from experiences and mistakes. Open their eyes to a universe of discovery. Allow them to take a walk in Galileo’s shoes and experience diversity, judgment, and compassion. Show them the way to invention and problem solving.

II. OVERVIEW

- A. Concept Objectives (List the same ones used within the individual lessons.)
 - 1. Understand the meaning of time and chronology.
 - 2. Use critical thinking and scientific problem solving to make informed decisions.
 - 3. Develop an awareness of place and understand the relative location of a place play a role in why events occur in certain places.
 - 4. Develop a sense of historical empathy.
 - 5. See through the eyes of people who were there.
- B. Content from the *Core Knowledge Sequence*
 - 1. The Renaissance and the Reformation
 - 2. A “rebirth” of ideas from ancient Greece and Rome
 - 3. New trade and new wealth
 - 4. Italian city states: Venice, Florence, Rome
 - 5. Patrons of the arts and learning
 - 6. The Popes and Rome
 - 7. Copernicus and Galileo: Conflicts between science and the church
 - 8. Ptolemaic (earth-centered) vs. sun-centered models of the universe
 - 9. The Reformation
 - 10. Gutenberg’s printing press: the Bible make widely available
 - 11. The Counter-Reformation
 - 12. Science Biographies: Galileo
- C. Skill Objectives
 - 1. The student will be able to analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information. (Science TEKS 5.3.A)
 - 2. The student will be able to evaluate the impact of research on scientific thought, society, and the environment. (Science TEKS 5.3.D)
 - 3. The student will be able to connect Grade 5 science concepts with the history of science and contributions of scientists. (Science TEKS 5.3.E)
 - 4. The student will be able to put in order a time line of events.
 - 5. The students will be able to identify the European countries: Italy, France, Switzerland, Austria, and Hungary
 - 6. The students will be able to identify the Italian cities: Pisa, Rome, Florence, Venice, Milan, Naples, and the Vatican City

7. The students will be able to identify the surrounding islands: Sicily, Corsica, and Sardinia.
8. The students will be able to identify the major body of water surrounding Italy: Mediterranean Sea
9. The student uses geographic tools to collect, analyze, and interpret data. (Social Studies-Geography TEKS 5.6)
10. The student will be able to write to express, discover, record, develop, reflect on ideas, and to problem solve (English TEKS 5.15.A)
11. The student will be able to demonstrate safe practices during field and laboratory investigations. (Science TEKS 5.1 A)
12. The student will be able to follow directions in order to assemble a designated final product.
13. The student will be able to communicate valid conclusions.
14. Collect and analyze information using tools. (TEKS 5.4A)
15. Plan and implement descriptive and simple experimental investigations... (TEKS 5.2A)
16. The students will be able to create a mini-replica of one of Galileo's discoveries, inventions, or improvements.

III. BACKGROUND KNOWLEDGE

- A. For Teachers
 1. Sis, Peter. *Starry Messenger*. New York: Farrar Straus Giroux, 1996.
 2. January, Brendan. *Science in the Renaissance*. United States: Franklin Watts, A Division of Grolier Publishing, 1999. 0-531-11526-7.
 3. Check out recommended websites under Resources.
- B. For Students
 1. Astronomy and Copernicus ~ 3rd Grade
 2. The Renaissance and the Reformation ~ 5th Grade

IV. RESOURCES

- A. Recommended Books
 1. Bolton, Sarah K. *Famous Men of Science*. New York: Thomas Y. Crowell Company, 1960.
 2. Hitzeroth, Deborah & Heerboth, Sharon. *The Importance of Galileo Galilei*. California: Lucent Books, 1992. 1-56006-027-1.
 3. Mason, Paul. *Galileo*. Illinois: Heinemann Library, 2001. 1-58810-052-9.
 4. McTavish, Douglas. *Pioneers of Science Galileo*. New York: The Bookwright Press, 1991. 0-531-18405-6.
 5. *Calliope, Exploring World History: Galileo*. A Cobblestone Publication. February 2004, Volume 14, Number 6
- B. Recommended Videos
 1. [Galileo: On the Shoulders of Giants](#) (2000) Producer: HBO The Inventors' Specials.
 2. [Genius: Galileo](#) (2001) Producers: Kultor Video
 3. [Galileo's Battle for the Heavens](#) Producer: PBS Nova
- C. Recommended Websites for background knowledge
 1. <http://www.pbs.org/wgbh/nova/galileo>
 2. <http://www.microscopy.fsu.edu/optics/timeline/people/galileo.html>
 3. <http://www.lucidcafe.com/library/96feb.galileo.html>

4. http://www.bbc.co.uk/history/historic_figures/galilei_galileo.shtml
5. http://www.fact-index.com/g/ga/galileo_galilei.html.
6. <http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Galileo.html>
7. <http://www-history.mcs.st-andrews.ac.uk/history/PictDisplay/Galileo.html>
8. http://www.tsl.state.tx.us/ld/projects/trc/2004/manual/internal_chapters/elementary_starrynights.htm
9. <http://www.hao.ucar.edu/public/education/sp/images/galileo.html>

V. LESSONS

Lesson One: A Moment in Time

A. *Daily Objectives*

1. Concept Objective(s)
 - a. Understand the meaning of time and chronology.
 - b. Use critical thinking and scientific problem solving to make informed decisions.
2. Lesson Content
 - a. The Renaissance and the Reformation
 - b. A “rebirth” of ideas from ancient Greece and Rome
 - c. New trade and new wealth
 - d. Italian city states: Venice, Florence, Rome
 - e. Patrons of the arts and learning
 - f. The Popes and Rome
 - g. Copernicus and Galileo: Conflicts between science and the church
 - h. Ptolemaic (earth-centered) vs. sun-centered models of the universe
 - i. The Reformation
 - j. Gutenberg’s printing press: the Bible made widely available
 - k. The Counter-Reformation
 - l. Science Biographies: Galileo
3. Skill Objective(s)
 - a. The student will be able to analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information. (Science TEKS 5.3.A)
 - b. The student will be able to evaluate the impact of research on scientific thought, society, and the environment. (Science TEKS 5.3.D)
 - c. The student will be able to connect Grade 5 science concepts with the history of science and contributions of scientists. (Science TEKS 5.3.E)
 - d. The student will be able to put in order a time line of events.

B. *Materials*

1. Appendix A (Timeline Events)
2. Appendix B (Background Information for Timeline Events)
3. Construction paper
4. Black markers
5. Yarn and Clothes pins

C. *Key Vocabulary*

1. Circa: approximate time; not knowing the exact time or date but “about”
2. Counter-Reformation: movement within the Catholic Church that aimed to make sure people followed the Church’s teachings

3. Heresy: going against the teachings of the Catholic Church
4. Hydrostatic balance: device for weighing things using water as the counter weight
5. Inquisition: group formed during the Counter-Reformation that made sure people followed the teachings of the Catholic Church by punishing people who went against the beliefs of the church
6. Planetary Theory: Belief held by someone about the center of the universe
7. Pendulum: weight that hangs down from a fixed point and can swing freely from side to side
8. Spyglass: early telescope

D. *Procedures/Activities*

1. Teacher cuts a length of yarn for the timeline. Attach it tightly to a wall for display of timeline pieces.
2. Teacher cut “Timeline Events” (Appendix A) into strips of individual events.
3. Introduce new unit on a Scientific Biography of Galileo, starting with a timeline of events leading up to and including his life.
4. From Appendix A (Timeline Events) teacher takes the first event: “Circa 300 B.C. Aristotle claimed that the earth was the center of the universe.” Teacher models on a piece of construction paper how to write large and put the date first and at the top center of the paper.
5. Teacher attaches the statement to the left side of the yarn timeline using a clothes pin. This starts the timeline of events for this unit.
6. Discuss the “B.C.” on the date and how it works. B.C. means “Before Christ” and is believed to be the time before the year in which Jesus Christ was thought to have been born.
7. Using the background information on Appendix B discuss the facts surrounding that statement.
8. With events out of order, give each pair of students a strip of the timeline.
9. Give students time to write the date and statement on their pieces of construction paper and look around at the other dates.
10. Recall the “B.C.” date on the timeline and ask is anyone has another event that happened before the “Birth of Christ”. (NO)
11. Which event would happen next then? Students may want to say their event prematurely, but be sure to take them in order. So, the discussion is chronological.
12. As students give their events, discuss each using the background information on Appendix B.

E. *Assessment/Evaluation*

1. Take all the events off the clothes pins and randomly pass these out to the students. Using a clock or stopwatch, time class on how fast they can line up in chronological order. Make it a game each day to review by seeing if they can beat the time from the day before. Note “Time to Beat” or “Best Time” on the board each day so students know.
2. Using Appendix A (Timeline Events) choose 5 random events from the bolded statements. Pull these events off the timeline and mix them up. Have students write them in chronological order on paper.

F. *Extension*

1. Choose one of the “Recommended Videos” under “Resources”. This will give students a clearer picture of Galileo’s life and goals.

Lesson Two: Where in the World?

A. *Daily Objectives*

1. Concept Objective(s)
 - a. Develop an awareness of place and understand the relative location of a place play a role in why events occur in certain places.
2. Lesson Content
 - a. Italian city states: Venice, Florence, Rome
3. Skill Objective(s)
 - a. The students will be able to identify the European countries: Italy, France, Switzerland, Austria-Hungary
 - b. The students will be able to identify the Italian cities: Pisa, Rome, Padua, Florence, Venice, and the Vatican City
 - c. The students will be able to identify the surrounding islands: Sicily, Corsica, and Sardinia
 - d. The students will be able to identify the major body of water surrounding Italy: Mediterranean Sea
 - e. The student uses geographic tools to collect, analyze, and interpret data. (Social Studies-Geography TEKS 5.6)

B. *Materials*

1. 2 inflatable globes
2. Overhead transparency and student handouts of Appendix C (Map of Italy)
3. Appendix D (Teacher Key of Map of Italy)
4. Various colored map pencils

C. *Key Vocabulary*

1. Compass rose: the symbol located on a map that shows the directions: North, East, South, and West
2. Island: a tract of land completely surrounded by water and not large enough to be called a continent
3. Legend: a table on a map that explains the symbols; a key
4. Peninsula: an area of land surrounded on three sides by water
5. Scale: a line or measurement indicated on a map that represents the actual distance in miles or kilometers

D. *Procedures/Activities*

1. Review timeline from lesson one stressing geographic areas.
2. Teacher models finding Italy on inflatable globe.
3. Teacher tosses globe to a student to locate Italy. Teacher tosses second globe to another student to locate Italy. Each student gets an opportunity to locate Italy and then toss the inflatable globe to another student.
4. Distribute Appendix C (Map of Italy) to each student and teacher uses transparency and discuss key vocabulary. This map is based on Galileo's time.
5. Teacher initiates discussion of landforms, stressing the difference between an island and a peninsula and defining.
6. Students locate Italy on their maps and identify it as an island or peninsula. (see key vocabulary)
7. Students are to locate and point to islands on their maps.
8. Teacher leads class in locating and labeling the islands. (Sicily, Corsica, Sardinia)

9. Teacher leads class in identifying surrounding countries (France, Switzerland, Austria-Hungary) labeling each on the transparency. Students label own maps.
 10. Teacher leads class in locating and labeling the Mediterranean Sea. Students label own maps.
 11. Teacher helps students recall the birthplace of Galileo and locate it on their maps. (Pisa)
 12. Teacher asks students about other important cities in Italy. (Rome, Florence, Venice, and Padua)
 13. Ask students what the capital of Italy is. (It is now Rome; however, at that time the church ruled and the Vatican City was the capital. Label it next to the star on their own map)
 14. Give students an opportunity to color maps using map pencils, and check for accuracy against the teacher transparency.
- E. *Assessment/Evaluation*
1. Teacher observation as students locate, label, and color maps.
 2. Check for student accuracy on maps.

Lesson Three: Taking a Walk in Galileo's Shoes (2 days)

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Develop a sense of historical empathy.
 - b. See through the eyes of people who were there.
 2. Lesson Content
 - a. The Renaissance and the Reformation
 - b. A "rebirth" of ideas from ancient Greece and Rome
 - c. The Popes and Rome
 - d. Copernicus and Galileo: Conflicts between science and the church
 - e. Ptolemaic (earth-centered) vs. sun-centered models of the universe
 - f. Gutenberg's printing press: the Bible made widely available
 - g. Science Biographies: Galileo
 3. Skill Objective(s)
 - a. The student will be able to analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information. (Science TEKS 5.3.A)
 - b. The student will be able to evaluate the impact of research on scientific thought, society, and the environment. (Science TEKS 5.3.D)
 - c. The student will be able to connect Grade 5 science concepts with the history of science and contributions of scientists. (Science TEKS 5.3.E)
 - d. The student will be able to write to express, discover, record, develop, reflect on ideas, and to problem solve (English TEKS 5.15.A)
- B. *Materials*
1. Appendix E (Far-Fetched Debate Topics)
 2. Student copies of Appendix F (Debate Rules)
 3. *Starry Messenger*, by Peter Sis or information from website: <http://www.hao.ucar.edu/public/education/sp/images/galileo.html>
 4. Student copies of Appendix G (Taking a Walk in Galileo's Shoes)
- C. *Key Vocabulary*

1. Debate: argue your side to persuade others
- D. *Procedures/Activities*
- Day 1**
1. Review time line.
 2. Put students into groups of three. Each group of three will become a debate team. Teacher assigns each debate team a topic. Be sure that opposing teams have related topics to debate. See Appendix E (Far-Fetched Debate Topics). These topics are meant to be ridiculous as was Aristotle’s earth-centered universe! Now that we know that!!!
 3. Actively discuss with students expectations for debate and what a debate is. They need to understand that in a debate each opponent is passionate about what they are debating. That they are arguing their point of view to persuade others to feel the way they do. Like politics, candidates try to persuade people to believe in what they are saying to get the voters’ votes. Handout Appendix F (Debate Rules) to students to use to prepare their teams.
 4. Give students time to prepare debate information and reasons for persuasion.
 5. Set classroom up for debate. Put two tables in front (one for each team) with a podium in between. Have a chalkboard or white board available for teams to use.
 6. Both opposing debate teams draw numbers to see which two sets of teams debate first.
 7. The first two teams take their seats at the table. Other students observe as audience members and record the perspective they agree with and state reasons why.
 8. Teams debate their side.
 9. When all teams have debated, discuss how it feels to strongly believe in a topic and how hard it is to persuade others to believe in your point of view.
- Day 2**
10. Read aloud *Starry Messenger* by Peter Sis or information from website.
 11. Use the debate activity and the book or website as a spring board to discuss how Galileo must have felt about having his work scrutinized by the Catholic Church and society as a whole. During this time the Catholic Church was the power and society believed in everything the Catholic Church claimed was truth. Church officials felt that Aristotle’s beliefs aligned with the Bible. However, neither the Catholic Church nor the Bible was around when Aristotle formed his theories.
- E. *Assessment/Evaluation*
1. **Day 1** While teams are debating topics, audience members are recording valid points mentioned by both sides. Once debate is complete, audience members choose a side to agree with and records why they agree.
 2. **Day 2** Using Appendix G (Taking a Walk in Galileo’s Shoes), have students write about how it must have felt to be Galileo being doubted by society and the church. Also, how Galileo must have felt about the Church having the authority to claim what was right and wrong.

Lesson Four: Moving and Grooving with a Can

F. *Daily Objectives*

1. Concept Objective(s)
 - a. See through the eyes of people who were there.
 - b. Use critical thinking and scientific problem solving to make informed decisions.

2. Lesson Content
 - a. The Renaissance and the Reformation
 - b. A “rebirth” of ideas from ancient Greece and Rome
 3. Skill Objective(s)
 - a. The student will be able to demonstrate safe practices during field and laboratory investigations. (Science TEKS 5.1 A)
 - b. The student will be able to follow directions in order to assemble a designated final product.
 - c. The student will be able to communicate valid conclusions.
- G. *Materials*
1. Coffee can (1 pound size, empty) per group.
 2. Coffee can lid (to fit the 1 pound can) per group.
 3. Rubber bands (3-4) per group.
 4. Washer (approximately ½ inch diameter) per group.
 5. Paper clips (2) per group.
 6. Ice pick (teacher use only)
 7. (Appendix H) Instructions for mobile coffee can (1 copy) per group.
- H. *Key Vocabulary*
1. mobile: movable
- I. *Procedures/Activities*
1. Before beginning this activity, teacher is to punch a hole in the center of the bottom of each coffee can and the center of each coffee can lid.
 2. Teacher groups four students to work together.
 3. Remind the students (using timeline) that in 1609 Galileo used the plans for the spyglass from another scientist to make his own. The students will be challenged today in the same manner. Add that Galileo actually improved on the design of the spyglass in his construction.
 4. Give each group of students the supplies needed for the mobile can.
 5. Hand out an Appendix H (Mobile Can Instructions) to each group of students.
 6. Inform students that each group will be attempting to take the materials given and make the same mobile can that is explained in the handout.
 7. Allow time for experimentation, discussion, problem solving, and construction.
 8. Once mobile cans are complete, allow groups to compare construction and test them. Look for: groups that improved the design and the group’s can that traveled the furthest distance.
- J. *Assessment/Evaluation*
1. Students self-evaluate themselves and each other using a 1 through 4 rating. 4 being the highest. 4 = 95 3 = 85 2 = 70 1 = 50
 2. You may want your students to write about their experience of building something from a list of directions.

Lesson Five: Galileo’s Telescope

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. See through the eyes of people who were there.
 - b. Use critical thinking and scientific problem solving to make informed decisions.
 2. Lesson Content

- a. A "rebirth" of ideas from ancient Greece and Rome.
 - b. Science Biographies: Galileo
 - 3. Skill Objective(s)
 - a. Collect and analyze information using tools. (TEKS 5.4A)
 - b. Plan and implement descriptive and simple experimental investigations... (TEKS 5.2A)
- B. *Materials*
 - 1. 2 lenses-one weak and one strong.
 - 2. 2 cardboard tubes (one should be able to slide into the other)
 - 3. small piece of aluminum foil
 - 4. tape or glue
 - 5. straight pin (for teacher only)
- C. *Key Vocabulary*
 - 1. *tele* Greek prefix "far off"
 - 2. *skopein* Greek verb "to see"
 - 3. *perspicillum* Latin Noun per "through"+ specere "to see" + ul "little"
 - 4. *telescope*: an instrument used to look at the stars and other planetary objects
- D. *Procedures/Activities*
 - 1. Begin constructing the telescope by constructing the barrel. Slide the tube with the smaller diameter into the tube with the larger diameter.
 - 2. Tape or glue one lens to the outside end of each tube.
 - 3. Point your telescope toward an object 10 to 15 feet away. Slide the barrels in and out to focus your telescopic image.
 - 4. By removing one eyepiece lens and replacing it with aluminum instead you can make your telescope zoom. Make a small pinhole through the foil.
 - 5. Look carefully through the pinhole.
- E. *Assessment/Evaluation*
 - 1. Using the telescopes to look at objects. On a nice day, take students outside to observe objects at a distance.
 - 2. Participation during the construction process.
 - 3. Sharing telescopes to see how each varies from another

Lesson Six: Galileo's Telescope Findings (4 days)

- A. *Daily Objectives*
 - 1. Concept Objective(s)
 - a. Use critical thinking and scientific problem solving to make informed decisions.
 - 2. Lesson Content
 - a. The Renaissance and the Reformation
 - b. A "rebirth" of ideas from ancient Greece and Rome
 - c. New trade and new wealth
 - d. Ptolemaic (earth-centered) vs. sun-centered models of the universe
 - e. The Counter-Reformation
 - f. Science Biographies: Galileo
 - 3. Skill Objective(s)
 - a. The students will be able to analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and

weaknesses using scientific evidence and information. (Science TEKS 5.3.A)

- b. The students will be able to evaluate the impact of research on scientific thought, society, and environment. (Science TEKS 5.3.D)
- c. The student will be able to connect Grade 5 science concepts with the history of science and contributions of scientists. (Science TEKS 5.3.E)
- d. The student will be able to write to express, discover, record, develop reflect on ideas, and to problem solve (English TEKS 5.15.A)

B. *Materials*

1. Access to encyclopedias, books, and internet
2. One Poster Board per group (5 groups)
3. Student copies of “Expectations for Posters/Suggested Websites” (Appendix I)

C. *Key Vocabulary*

1. spyglass: that is what the very first telescopes were called

D. *Procedures/Activities*

Day 1 & 2

1. Remind students of Galileo’s reinvention of the spyglass (telescope) in 1609. After this event, Galileo focused his attention to the skies. In 1610, he discovered four major happenings in the sky: the four moons of Jupiter, the rings of Saturn, the phases of Venus, and the Sunspots.
2. Put students into six groups. Each group will create a poster using Appendix I (Expectations for Poster/Suggested Websites). Using encyclopedias, books, and websites, each group will investigate one of the following topics for their poster:
 - a. The four moons of Jupiter
 - b. The rings of Saturn
 - c. The Phases of Venus
 - d. The Sunspots
 - e. Galileo’s Telescope
 - f. Galileo, the Spacecraft
3. Give students 2 days to research their assigned topic.

Day 3

4. Groups organizing data onto their poster board. Have students refer back to Appendix I.

Day 4

5. Students become the teachers for the day. Each group will share their poster with the class. Give them time to answer questions from the class. Have the group pick a spot in the classroom (or hallway) to hang their poster.
6. After each group have shared their poster with the class, give students time to walk around to each poster taking a closer look at the information.

E. *Assessment/Evaluation*

1. For day 1-3, observe students as they work in groups. Possible participation grade.
2. After group posters are complete, use Appendix J (Poster Rubric) to grade projects.
3. Have students rate each group member’s participation.

Lesson Seven: Falling Bodies

F. *Daily Objectives*

1. Concept Objective(s)

- a. Understand the meaning of time and chronology.
 - b. Use critical thinking and scientific problem solving to make informed decisions.
2. Lesson Content
- a. A “rebirth” of ideas from ancient Greece and Rome
 - b. Copernicus and Galileo: Conflicts between science and the church
 - c. Science Biographies: Galileo
3. Skill Objective(s)
- a. Collect and analyze information using tools. (TEKS 5.4A)
 - b. Plan and implement descriptive and simple experimental investigations... (TEKS 5.2A)

G. *Materials*

- 1. Beanbags or rocks of various weights (bouncy balls are not recommended because of the distraction of the bounce when it hit the ground.)
- 2. Adding machine tape
- 3. Tape
- 4. Chair
- 5. Stop watch
- 6. Yard or meter sticks
- 7. Graph paper
- 8. Map pencils

H. *Key Vocabulary*

- 1. mass: a body of matter holding or sticking together with out a particular shape, size, or bulk

I. *Procedures/Activities*

- 1. Teacher Background: With Aristotle’s influences, people believed that if two bodies of different masses were dropped from the same height at the same time, the heavier one would hit the ground first. At the end of the 1500’s, Galileo believed differently. He reasoned that if two bricks of the same mass fall side by side, at the same speed, they should fall at the same speed even when cemented together hitting the ground at the same time. Therefore, a single brick would fall just as fast as the heavier two bricks cemented together. Other scientist at the time disagreed with Galileo. According to legend, in 1590, Galileo proved his theory at the famous Leaning Tower of Pisa. Galileo went to the top of the tower with two canon balls of different sizes. He dropped them both at the same time. There was a small difference, but not nearly so great as the difference between their weights. He concluded that it was the resistance of the air that caused the difference in time between the falling of the two balls. Whether or not Galileo actually conducted this experiment on the Tower of Pisa, his reasoning about the result was correct. (May choose to share information AFTER experiment as to not influence predictions within experiment. Also may want to show pictures of the Tower of Pisa to make a connection with Social Studies and Science.)
- 2. Introduce Scientific Method (1. Ask question. 2. Predict. 3. Experiment. 4. Record Observation. 5. Conclusion.)
- 3. The question for the experiment is, “Will two objects of different weights hit the ground at the same time when dropped from the same height?”
- 4. Allow students to predict and teacher records predictions on the board.
- 5. Put students into groups of four. Each person in the group will be assigned a job.
 - 1. Object Dropper. 2. Recorder. 3. Time Keeper. 4. Task Master.

6. Task Master will use a yardstick to measure and locate on adding machine tape, 2 feet, 4 feet, 6 feet, and 8 feet.
 7. Group will find a place in the room to hang their adding machine measuring tape. (Teacher supervises students to be sure that each tape is started at the ground. ie. No gaps between floor and tape.)
 8. The object dropper will drop two objects of different weights from 2 feet releasing the objects at the same time while Time Keeper measures the time from drop to hit. Recorder records the feet and time for the experiment. The Task Master helps the Time Keeper and Recorder. He/She also keeps the group on task.
 9. Repeat instructions from above (#8) for 4 feet, 6 feet, and 8 feet.
 10. Using graph paper, the group will create a graph representing the experiment information. Students may make a bar graph, picture graph, or line graph.
 11. When graph is complete, students write their conclusion in paragraph form answering the question for the experiment (from Procedure #3).
- J. *Assessment/Evaluation*
1. Observe students conducting experiment.
 2. Graph and conclusion paragraph.
 3. Students will self and peer evaluate (Appendix K)

Lesson Eight: Galileo's Time Capsule

- A. *Daily Objectives*
1. Concept Objective(s)
 - a. Understand the meaning of time and chronology.
 - b. Develop an awareness of place and understand the relative location of a place play a role in why events occur in certain places.
 - c. Develop a sense of historical empathy.
 - d. See through the eyes of people who were there.
 2. Lesson Content
 - a. A "rebirth" of ideas from ancient Greece and Rome
 - b. Copernicus and Galileo: Conflicts between science and the church
 - c. Ptolemaic (earth-centered) vs. sun-centered models of the universe
 - d. Science Biographies: Galileo
 3. Skill Objective(s)
 - a. The students will be able to evaluate the impact of research on scientific thought, society, and the environment. (Science TEKS 5.3.D)
 - b. The student will be able to connect Grade 5 science concepts with the history of science and contributions of scientists. (Science TEKS 5.3.E)
 - c. The students will be able to write to express, discover, record, develop, reflect on ideas, and to problem solve. (Science TEKS 5.15.A)
 - d. The students will be able to create a mini-replica of one of Galileo's discoveries, inventions, or improvements.
- B. *Materials*
1. Canisters for time capsule (Crystal Light containers, Pringles cans, or shoe boxes work nice!)
 2. Construction paper
 3. Variety of craft supplies (examples)
 - a. Toilet paper tubes

- b. Paper towel tubes
 - c. String
 - d. Cotton balls
 - e. Cups of various sizes
 - f. Glitter
2. Time line present
- C. *Key Vocabulary*
- 1. time capsule: a place people store important things from today and put away for so people can see what things were like in the past
- D. *Procedures/Activities*
- 1. Start by having a discussion with the students about all the things Galileo discovered, invented, or improved upon. May want to refer back to timeline. As students discuss ideas and brainstorm together, list ideas on the board.
 - 2. Ask students which discovery, invention, or improvement do they think Galileo was most proud of and would want to put in a time capsule. (May need to discuss what a time capsule is.) Let students share their ideas in small groups encouraging them to give reasons for their ideas.
 - 3. Inform students that they are going to be Galileo and create a time capsule with what they think he would want people of the future to find and experience first hand from him. This will include a writing from Galileo and a mini-replica of one of his ideas.
 - 4. Students begin by writing their explanation from Galileo. They need to identify the discovery, invention, or improvement and describe it. They must include at least three reasons why this would be the one that Galileo was most proud of. May want to write expectations on board.
 - 5. As students complete their writing, give them construction paper and a container to decorate their time capsule.
 - 6. HOME PROJECT: Give students two or three days at home to complete. Students will create a mini-replica of their chosen discovery, invention, or improvement to put in their time capsule. Encourage students to use a variety of craft supplies to create their mini-replica. Have some materials for students to start using or to get ideas from.
 - 7. Put both, writing and mini-replica, in the time capsule.
 - 8. Have students share their projects with the class.
- E. *Assessment/Evaluation*
- 1. Grade writings based on teacher expectations for students.
 - 2. Creativeness for mini-replicas.

VI. CULMINATING ACTIVITY

A. A Starry Night Festival

Begin organizing the festival *before* beginning this unit. You will need to contact your local planetarium or observatory. Stargazing is a very popular pastime and bookings fill up quickly in the early fall months. Have the local members bring telescopes for viewing the night sky. Center your festival around this booking. Recruit parents to make celestial shape cookies and finger sandwiches. Set up booths using student work and assign each student a shift at a booth to present, explain, and answer questions. You could also present a slide show or power point presentation of all the excitement and learning involved

throughout the Galileo unit. Take the festival to a higher level by encouraging students and teachers to dress up from the Renaissance period.

VII. HANDOUTS/WORKSHEETS (See Appendices)

- A. Appendix A - Timeline Events
- B. Appendix B – Timeline Events (Teacher Notes)
- C. Appendix C – Map of Italy
- D. Appendix D – Map of Italy (Teacher Key)
- E. Appendix E – Far Fetched Debate Topics
- F. Appendix F – Debate Rules
- G. Appendix G – Taking a Walk in Galileo’s Shoes
- H. Appendix H – Mobile Can Instructions
- I. Appendix I – Expectations for Posters/Suggested Websites
- J. Appendix J – Poster Rubrics
- K. Appendix K – Self and Peer Evaluation

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Appendix A
Timeline Events
Lesson 1

- Circa 300 B.C.: Aristotle claimed that the earth was the center of the universe.
- A.D. 140: Ptolemy published *The Greater Astronomical Syntax*, which supported Aristotle's view of the workings of the universe.
- 1440: Johann Gutenberg first experiments with movable type and the printing press is invented making it possible to spread new scientific ideas quickly.
- 1455: The first mechanical printing of a book. (Bible)
- 1482: Christopher Columbus discovered America.
- 1543: Nicolaus Copernicus developed a theory that the sun is the center of the universe and that all of the planets rotate around the sun in his book *De Revolutionibus Oribum Caelestium*.
- 1564: Galileo Galilei was born in Pisa on February 15.
- 1564: Michael Angelo died in Rome on February 18.
- 1564: William Shakespeare was born in England on April 16.
- 1600: Giordano Bruno burned at the stake for claiming that the earth orbits the sun.
- 1609: Galileo learns of the spyglass, the first telescope, and gets plans to make his own.
- 1615: Warnings of Galileo's ideas first brought to the attention of the Inquisition.
- 1620: The Mayflower lands at Plymouth Rock.

- 1630: Galileo completes the *Dialogue* in January.
- 1632: Publication of the *Dialogue* with the preface included.
- 1632: First official document showing the church's changing attitude toward Galileo.
- 1633: Galileo arrives in Rome to face the Inquisition on February 13.
- 1633: On June 22 Galileo is accused of heresy and placed under house arrest for the remainder of his life.
- 1642: In January, Galileo dies at the age of seventy-seven.
- 1642: On Christmas Day, Isaac Newton was born.
- 1992: The Catholic Church pardoned Galileo.

Appendix B
Timeline Events (Teacher Notes)
Lesson 1

- Circa 300 B.C.: Aristotle claimed that the earth was the center of the universe.
 - One of the first astronomers and first to document the study of stars and planets. At this time, his ideas were only supported through observation of the naked eye (because telescopes or any other instruments were not invented yet). His findings were *later* supported by the Catholic Church.

- A.D. 140: Ptolemy published *The Greater Astronomical Syntax*, which supported Aristotle's view of the workings of the universe.
 - One of the most famous ancient astronomers and also a mathematician and geographer. Living in Egypt, he developed his theory that the Earth was the center of the universe. This was supported by the Catholic Church because it went along with the Scriptures and remained unquestioned for fourteen hundred years.

- 1440: Johann Gutenberg first experiments with movable type and the printing press is invented making it possible to spread new scientific ideas quickly.

- 1455: The first mechanical printing of a book. (Bible)

- 1482: Christopher Columbus discovered America.
 - The voyages of Christopher Columbus opened up European colonization to the New World.
 -

- 1543: Nicolaus Copernicus developed a theory that the sun is the center of the universe and that all of the planets rotate around the sun in his book *De Revolutionibus Oribum Caelestium*.
 - Nicolaus started out his study supporting Ptolemy. After much research, he became dissatisfied with Ptolemy's explanation. Copernicus changed his thinking which went against church thinking. His theory was based without using modern instruments, however he cut slits in the walls of his observation room to take notes of the motion of the stars and planets. He provided tables and charts of his data which remained in use long after he died.

- 1564: Galileo Galilei was born in Pisa on February 15.
 - He had been born into one of the most powerful families in Florence, but by the time Galileo was born his parents were struggling for money. He was the oldest of five children and his parents never married. His father wanted him to be a doctor so he would have the finances to support the family. At University of Pisa, he found that he had a passion for math and science. Later he became a professor there. He was expected to teach

Aristotle's point of view. This was difficult for him because he believed an idea could only be accepted once tested and proven.

- 1564: Michael Angelo died in Rome on February 18.
- 1564: William Shakespeare was born in England on April 16.
- 1600: Giordano Bruno burned at the stake for claiming that the earth orbits the sun.
 - Galileo was working on his planetary theory at this time. Imagine how Galileo must have felt finding out about this!
- 1609: Galileo learns of the spyglass, the first telescope, and gets plans to make his own.
 - His telescope ended up being better than the original. He told the Senate of Venice not to buy it, that his was better. The Senate viewed ships that were too far out of the harbor. They approved.
- 1615: Warnings of Galileo's ideas first brought to the attention of the Inquisition.
 - After reading a letter written by Galileo to a family friend, Father Benedetto Castelli, supporting Copernicus's Heliocentric theory (Sun centered universe), Father Nicolo Lorini wrote to the Inquisition because this belief was considered an act of heresy. During the Inquisition, anyone suspected of believing in the Copernian view could be questioned, tortured, imprisoned, or burned at the stake.
- 1620: The Mayflower lands at Plymouth Rock.
- 1630: Galileo completes the *Dialogue* in January.
 - Galileo wrote this book in the form of a conversation between three friends. One friend an Aristotelian philosopher, one a scientist, and one a gentleman open to persuasion. This allowed him to introduce a wide variety of ideas without being personally responsible for them. His book was approved and published by the Catholic Church. The preface of the book was written under the Pope's direction and was accepted as not showing heresy.
- 1632: Publication of the *Dialogue* with the preface included.
- 1632: First official document showing the church's changing attitude toward Galileo.
 - A letter was sent from Father Riccardi to the Inquisition questioning Galileo's beliefs. Galileo is ordered to "correct" the *Dialogue*.
- 1633: Galileo arrives in Rome to face the Inquisition on February 13.
 - By this time, Galileo was very old and sick. It took twenty-three days to arrive in Rome from Florence being carried all the way.

- 1633: On June 22 Galileo is accused of heresy and placed under house arrest for the remainder of his life.
 - He was forced to denounce his beliefs in front of the Inquisition on bended knee. But as he stood to accept his sentence, he whispered, “*Eppur si muove*”—“The earth does move.” This act of defiance may have cost others their life. His house arrest was carried out at the home of the archbishop of Siena. Galileo was not allowed to be with his family, however he was allowed to write them. He wrote another book, *Two New Sciences*, while under house arrest, written in dialogue form by the same three friends. The book discussed mechanics and motion. His work was no longer accepted in Italy. The book was smuggled to the Netherlands where it was published in the spring of 1638. By the time Galileo received a copy of his book, he was blind.

- 1642: In January, Galileo dies at the age of seventy-seven.

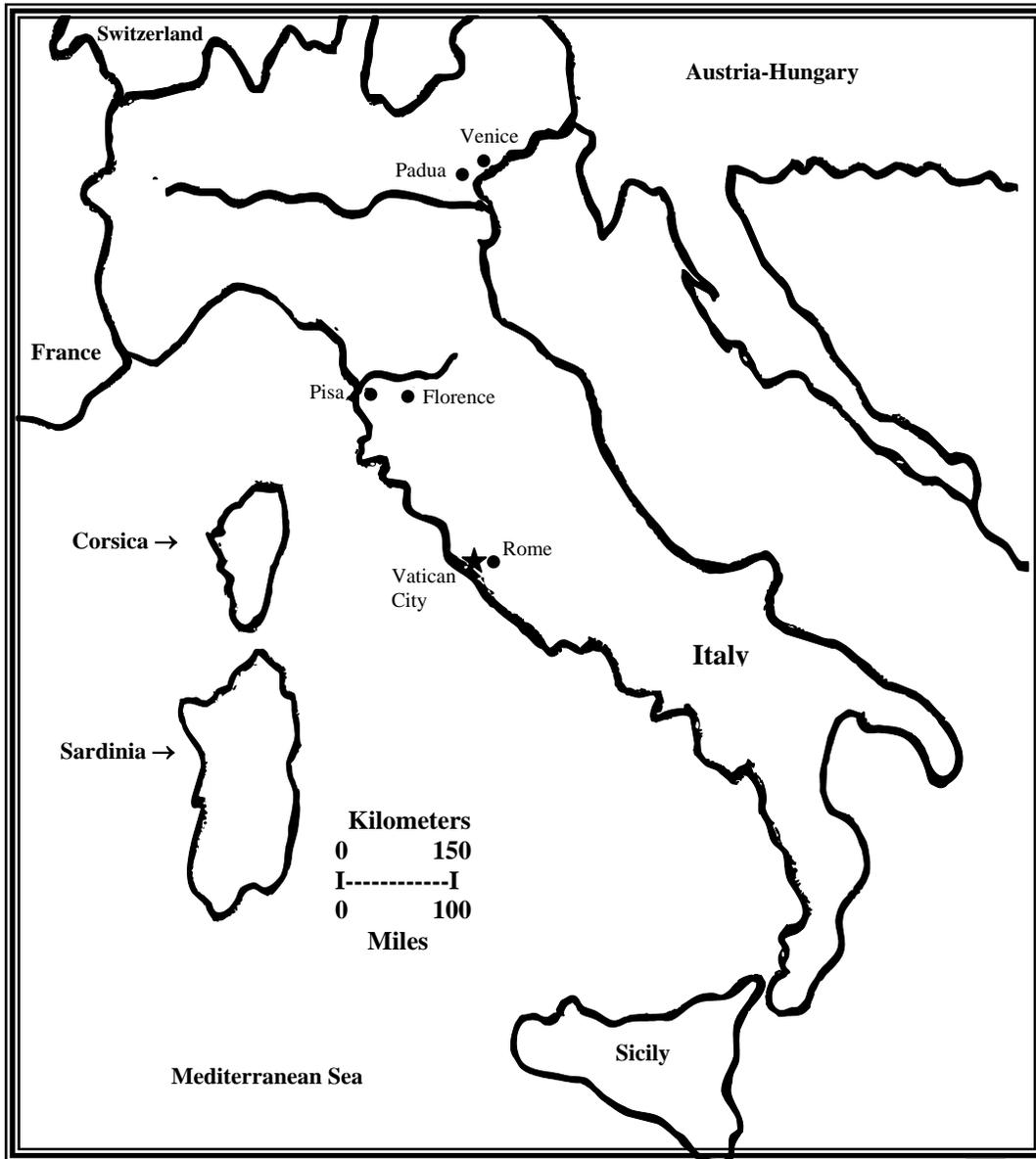
- 1642: On Christmas Day, Isaac Newton was born.
 - Newton used Galileo’s “The Law of Inertia” as the foundation for his “First Law of Motion.”

- 1992: The Catholic Church pardoned Galileo.

Appendix C
Map of Italy
Lesson 2



Appendix D
Map of Italy ~ Teacher Key
Lesson 2



Appendix E
Far-Fetched Debate Topics
Lesson 3 Day 1

1. **Sky Color**
One team takes the side that the sky is purple and the other team takes the side that it is blue.
2. **The Moon**
One team takes the side that the moon is now orbiting the sun between Venus and Earth. The other side defends the moon's current path.
3. **The Earth**
One team takes the side that the earth is getting larger and the other that the earth is getting smaller.
4. **The Sun**
One team takes the side that the sun is a liquid and the other team takes the side that the sun is a liquid.
5. **The Moon**
One team takes the side that the moon is deteriorating (phases of the moon!!) and the other defends its current state.
6. **The Icebergs**
One team takes the side that the icebergs are melting rapidly and the other team takes the side that the icebergs are increasing in size.

Appendix F
Debate Rules

Lesson 3 Day 1

Taken and Revised from website:

http://www.lalc.k12.ca.us/uclasp/ISSUES/bringing_water/debate.htm

Far-Fetched Debate Topic: _____

Opposition: _____ **Proponents:** _____

You are now a member of your selected team. Your team will be graded as a whole. This means that you will be as strong as your weakest link. Be sure that you work together so that all members of your team have an adequate background of the positions and arguments that you will be presenting.

1. There will be an opening statement made by your team. This should be 3-5 minutes long and should state your team's position and the arguments/reasons you will be proposing.

Responsible Members: _____

2. You should have 8 – 10 questions that can be asked of each of your 3 opponents. These should be on separate sheets of paper or on note cards for easy reference. The questions should be specifically directed to your opponents and should be straight to the point and clear.

Responsible Members: _____

3. You should have answers prepared which will be used to respond to your opponents' questions. Imagine you are from the other teams and determine what questions they may ask of your team.

Responsible Members: _____

4. You should have a final conclusion ideas jotted down which will be written at the end of your debate. This should be no longer than 5 minutes. You should take notes during the entire debate so that you may refer to these in your final presentation of your team's views.

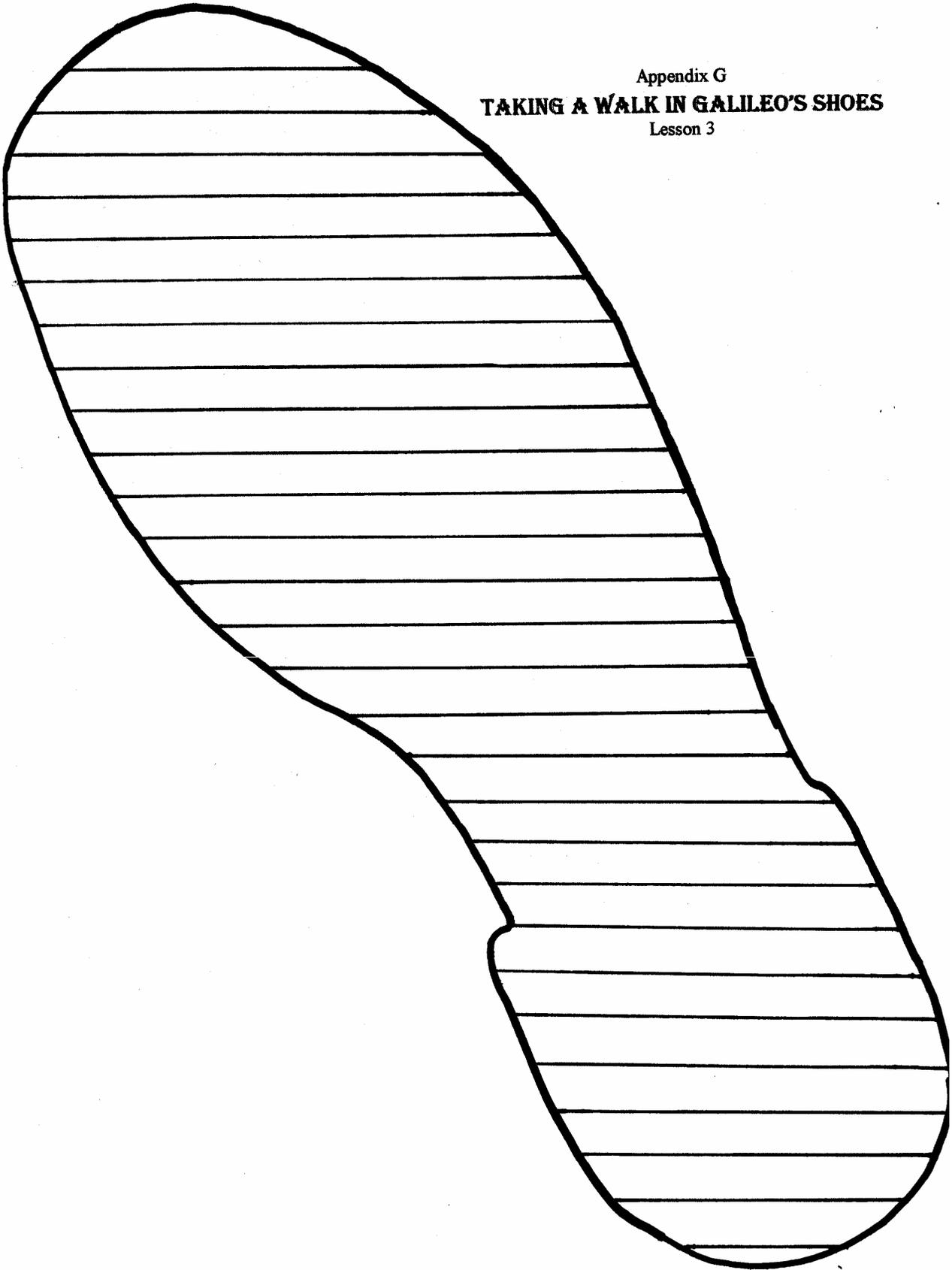
Responsible Members: _____

When you have determined who will be responsible for each portion of your team's debate, it is up to you to prepare yourself for the challenge that lies ahead. Only one team will win this debate. The winning team will:

- have a solid background regarding all material.
- have plenty of evidence to back up claims.
- use teamwork to teach all in group the important concepts behind.
- strong argument for your position
- be creative
- psyche out opponents
- outclass opponents (don't make it a shouting match!)
- never give an answer of "Uh..."

Good luck! This assignment is worth 100 points and will be graded based upon your ability to debate the issue and convince the audience that you are indeed deserved of your claim.

Appendix G
TAKING A WALK IN GALILEO'S SHOES
Lesson 3



Appendix H
Mobile Can Instructions
Lesson 4

Galileo heard of a telescope that was invented in another country. He was fascinated by the possibilities that such an instrument could provide in his astronomical research. He obtained copies of the instructions from the man that invented it and proceeded to construct a telescope of his own. Galileo eventually surpassed the original design and created a more powerful telescope. However, he did not come up with the idea on his own, instead he improved upon the instructions he received.

Using the supplies provided, you will work with your team to create a mobile can. Be sure to follow the instructions carefully as the end product could be jeopardized otherwise.

2. Using the rubber bands and the washer, tie one end of one rubber band to the washer. Tie the other rubber band to the washer across from the first rubber band.
3. Thread the end of one rubber band through the hole in the lid of the can. Using a paper clip, secure the rubber band in place by sliding the rubber band through the paper clip. (The paper clip should lay flat against the top, outside of the can lid. The rubber bands and washer should dangle down securely if the lid is held up.)
4. Thread the other rubber band end through the hole in the bottom of the can. Using the other paper clip, secure the rubber band in place by sliding the rubber band through the paper clip.
5. Secure the lid onto the can. If the two rubber bands are not pulled tight within the can, pull the paper clips away from the can and add a knot to each end. You must have a taut rubber band in the can for the experiment to work.
6. Once your construction is complete, roll the can across the room in one direction. When the can is released it should roll back in the opposite direction that it was rolled.

Extension: Allow students to try to improve on the mobile can. Try to change the construction to make it faster. May wish to organize can races down the hallway.

Appendix I
Expectations for Posters/Suggested Websites
Lesson 5

Expectations:

- Posters must have an **Illustration**, a picture that has something to do with your topic.
- Posters must have a **Summary**, one to two paragraphs written in own words and must have 6-10 facts from reliable sources.
- Posters must have an **Opinion paragraph**, student opinion must be supported with reasons.
- Posters must have **Resources cited**, students should take time to cite a variety of resources used to complete the poster project.
- Posters must be **Neat**, students should take care and pride in work for this presentation.

Suggested Websites:

1. Jupiter and extra links: www.galileo-galilei.org/
2. Galileo and his telescope:
<http://outreach.atnf.csiro.au/education/senior/astrophysics/galileo.html>
3. Galileo the space probe: www.cloudynights.com/observation/october.html
4. Sunspots: www.exploratorium.edu/sunspots/index.html
5. Background (also good for “Saturn” and “Venus”):
www.zephyrus.co.uk/galileogalilei.html
6. Saturn: <http://es.rice.edu/es/humsoc/galileo/things/saturn.html>
7. Venus: www.worldbook.com/features/venus/html/phasesgalileo.html

Appendix J

Poster Rubrics

Lesson 5

Poster must include:

_____ An illustration that supports the assigned topic. (20 points)

_____ A summary of the topic. (25 points)

1-2 paragraphs, written in own words

6-10 facts from reliable sources

_____ Opinion paragraph (20 points)

Student must support his or her opinion

_____ Resources Cited (10 points)

These are to be listed on the back of the poster

_____ Group member names (5 points)

These are also to be listed on the back of the poster

_____ Neatness Counts! (10 points)

The overall appearance of the poster and work should be neat and legible. Stress to students that the posters will be displayed at the Starry Nights Festival.

_____ Presentation of Topic (10 points)

Appendix K
Self and Peer Evaluation
Lesson 7

Ratings:

- 4 very involved and helpful
- 3 involved and pretty helpful
- 2 involved some of the time and not very helpful
- 1 not involved and not helpful
- 0 did nothing

Students use the rating scale to rate themselves and group members. Write the name of each member next to his title and rate. You may want to put reasons for your rating. This rating gets turned in to the teacher.

Task Master:

Time Keeper:

Recorder:

Object Dropper:

