Module 2: Motion
3rd Grade

About the Instructions:

This document is intended for use by classroom teachers, SciTrek leads, and SciTrek volunteers. The document has been composed with input from teachers, leads, volunteers, and SciTrek staff to provide suggestions to future teachers/leads/volunteers. The instructions are not intended to be used as a direct script, but were written to provide teachers/leads/volunteers with a guideline to present the information that has worked in the past. Teachers/leads/volunteers should feel free to deviate from the instructions to help students reach the learning objectives of the module. Places in which you can be creative and mold the program to meet your individual teaching style, or to meet the needs of students in the class are: during class discussions, managing the groups/class, generating alternative examples, and asking students leading questions. However, while running the module make sure to cover all the material each day within the scheduled 60 minutes. In addition, no changes should be made to the academic language surrounding questions or the Question Activity.

Activity Schedule:

There are no scheduling restrictions for this module.

Day 1: Question Assessment/Technique/Observations/Reproducibility Discussion/Variables (60 minutes)
Day 2: Question Activity/Questions/Materials Page/Experimental Set-Up (60 minutes)
Day 3: Technique/Procedure/Results Table/Experiment (60 minutes)
Day 4: Graph/Results Summary/Poster Making (60 minutes)
Day 5: Poster Presentations (60 minutes)
Day 6: Question Assessment/Draw a Scientist/Tie to Standards/Content Assessment (60 minutes)

The exact module dates and times are posted on the SciTrek website (http://www.chem.ucsb.edu/scitrek/elementary) under the school/teacher. The times on the website include transportation time to and from the SciTrek office (Chem 1105). Thirty minutes are allotted for transportation before and after the module, therefore, if a module was running from 10:00-11:00 then the module times on the website would be from 9:30-11:30.

Student Groups:

Students are divided into four groups of ~five students each for the entire module. One volunteer is assigned to help each group. We find groups work best when they are mixed levels and mixed language abilities.

NGSS Performance Expectation Addressed:

3-PS2-2 Make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion.

Common Core Mathematics Standard Addressed:

3.NF-1 Understand a fraction 1/b as the quantity formed by 1 part when a whole is partitioned into b equal parts; understand a fraction a/b as the quantity formed by parts of size 1/b.
Learning Objectives:

1. Students will know that an object’s motion is predictable and will be able to predict the outcome of an experiment based on previous data.
2. Students will know the importance of repeating their experiments.
3. Students will be able to find the median number of a given set of numbers composed of an odd number of data points.
4. Students will be able to generate at least two testable questions and recognize when questions are not testable by science.
5. Students will be able to suggest revisions for questions that are not testable by science in order to make them testable.
6. Students will be able to list at least one way that they behaved like scientists.

Classroom Teacher Responsibilities:

In order for SciTrek to be sustainable, the program needs to work with teachers on developing their abilities to run student-centered inquiry-based science lessons on their own in their classrooms. As teachers take over the role of SciTrek lead, SciTrek will expand to additional classrooms. Even when teachers lead the modules in their own classrooms, SciTrek will continue to provide volunteers and all of the materials needed to run the module. Below is a sample timeline for teachers to take over the role as the SciTrek lead.

*Groups are made up of ~five students.

1. Year 1
   a. Classroom teacher leads a group (Role: Group Lead; this is referred to as a volunteer in these instructions)

2. Year 2
   a. Classroom teacher co-leads the modules with a SciTrek staff member (Role: Co-Lead)
      i. Classroom teacher will be responsible for leading entire class discussions (Ex: Question Activity).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.
      iv. Classroom teacher will be responsible for all above activities, the SciTrek co-lead will only step in for emergencies.
      v. The SciTrek co-lead will run the Tie to Standards Activity.

3. Year 3 and beyond
   a. Classroom teacher leads the modules (Role: Lead)
      i. Classroom teacher will be responsible for leading entire class discussions (Ex: Question Activity).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.
      iv. A SciTrek staff member will co-lead the Tie to Standards Activity with the classroom teacher for year 3.

SciTrek staff is counting on teacher involvement. Teachers should notify the SciTrek staff if they will not be present on any day(s) of the module. Additional steps can be taken to become a SciTrek lead faster than the proposed schedule above. Contact scitrekelementary@chem.ucsb.edu to learn more.
In addition, teachers are **required** to come to UCSB for the module orientation, ~one week prior to the start of the module. Contact scitrekelementary@chem.ucsb.edu for exact times and dates, or see our website at [http://www.chem.ucsb.edu/scitrek/elementary](http://www.chem.ucsb.edu/scitrek/elementary) under your class’ module times. At the orientation, teachers will go over module content, learn their responsibilities during the module, and meet the volunteers that will be helping in their classroom. If you are not able to come to the orientation at UCSB, you must complete an online orientation. Failure to complete an orientation for the module will result in loss of priority registration for next year.

**Prior to the Module (at least 1 week):**

1. Come to the SciTrek module orientation at UCSB.

**During the Module:**

If possible, have a document camera available to the lead every day of the module. If you do not have a document camera, please tell the SciTrek staff at orientation.

**Days 1 and 3:**

- Have four floor spaces available for the students. Each group will need a ~5 ft x 2 ft floor space for the ramp set-up, as well as additional space for ~five students to sit.

**Days 2, 3, and 4:**

- Have the students’ desks/tables moved into four groups and cleared off. This ensures that each student has a desk during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

**Days 5-6:**

- Have the students’ desks/tables cleared off. The desks/tables do not need to be moved into groups.

**Scheduling Alternatives:**

Some teachers have expressed interest in giving the students more time to work with the volunteers throughout the module. Below are options that will allow the students more time to work with the volunteers. If you plan to do any of the following options, please inform the SciTrek staff no later than your orientation date (~one week before your module, exact orientation times are found at: [http://www.chem.ucsb.edu/scitrek/elementary](http://www.chem.ucsb.edu/scitrek/elementary)). This will allow the SciTrek staff to provide you with all needed materials.

**Day 1:**

If you would like to have more time for your students to make observations and generate variables, you can do one or both of the following activities **before** SciTrek arrives:

1) Question Assessment
2) Technique Activity

**Day 2:**

If you would like to have more time for your students to generate testable and non-testable questions and design their experiments, you can go over the Question Activity **before** SciTrek arrives.
Day 3:
If you would like to have more time for your students to perform their experiments, you can do the Technique Activity before SciTrek arrives.

Day 5:
If you would like to have more time for your students to discuss their experiments during poster presentations, you may take more time for each presentation and finish the presentations after SciTrek leaves.

Day 6:
If you would like more time for the Tie to Standards Activity, you may give the Question Assessment before SciTrek arrives.

**Materials Used for this Module:**

1. Outdoor Carpet (Home Depot part number: Elevation Stone Beige 0000-512-400) cut into 6 ft x 2 ft pieces. One of the 6 ft x 2 ft outdoor carpets is marked with a permanent marker to show the 50 cm, 100 cm, and 150 cm mark. This carpet is only used on the Tie to Standards day. In addition, the appropriately sized outdoor carpet is hot glued to all of the ramps. See description listed under Particle Board.

2. Shag Carpet (Home Depot part number: Palmetto Sandalwood 0000-763-088) cut into 100 cm x 30 cm pieces. In addition, 50 cm x 30 cm pieces of the shag carpet are hot glued to 50 cm x 30 cm ramps for the initial observation.

3. Astroturf (Home Depot) cut into 125 cm x 30 cm pieces. In addition, 50 cm x 30 cm pieces of Astroturf are hot glued to 50 cm x 30 cm ramps for the initial observation and the Tie to Standards. One of the 125 cm x 30 cm Astroturf pieces is marked with masking tape and a permanent marker. At 50 cm there is a mark that says 100 cm, and at 100 cm there is a mark that says 150 cm (the units are 50 cm off because the ramp is the initial 50 cm). This material is only used on the Tie to Standards day.

4. 0.5 in Particle Board (Home Depot) cut to 45 cm x 30 cm, 50 cm x 30 cm, 55 cm x 30 cm, 60 cm x 30 cm, 65 cm x 30 cm, 70 cm x 30 cm, 75 cm x 30 cm, and 80 cm x 30 cm, 100 cm x 30 cm. All boards have outdoor carpet hot glued onto one of the sides except some of the 30 cm x 65 cm (these boards are used for ball stops) and the 100 cm x 30 cm (these boards are used for the Tie to Standards) boards.

5. Rulers (Office Depot part number: 21215472)

6. MyChron Timers (Fisher Part Number: S65330) and replacement batteries (Fisher Part Number: 50-212-755)

7. 152 cm/60” flexible measuring tape (ETA hand2mind Part number: IN524)

8. 300 cm/120” tailor craft flexible ruler tape measure yellow by Amico (Amazon)

9. Large Binder Clips 2” size with 1” capacity (Staples part number: 329502)

10. Lab Jacks 8 in x 8 in (Fisher Part Number: S63082)

11. Wood ramp holders. These are made by cutting a 4”x4” 12 cm tall and then cutting the top to a 14° angle on the top or by cutting a 4”x4” 21 cm tall and then cutting the top to a 24° angle. The backs of the wood ramp holders are covered with a .5” board that sticks 3.5” above the top. See picture below.
12. Digital Scale (OHAUS, max weight: 2000g, readability: 1 g, Model No. H-2715) (Fisher Part Number: S40242-1)

13. Plastic Handmade Balls
   Masses of 27 cm circumference balls: ~55 g, ~100 g, ~165 g, ~200 g, ~265 g, ~305 g, ~360 g
   Circumferences of ~200 g gram balls: 18 cm, 21 cm, 24 cm, 27 cm, 30 cm, 33 cm

All printed materials used by SciTrek (student notebooks, materials page, lead picture packet, poster parts, instructions, and nametags) can be made available for use and/or editing by emailing scitrekelementary@chem.ucsb.edu.

Types of Documents:

Student Notebook:
   One given to every student and is filled out by the student. In these instructions, the examples are rectangular and filled out in black. The lead will use a student notebook to write in as an example for students. The notebook that the lead uses is referred to as the class notebook in these instructions.

Notepad:
   One given to every group and is filled out by the volunteer. In these instructions, the examples are squarer and filled out in blue.

Picture Packet:
   One per class that, if needed, the lead fills out. In these instructions, the examples are rectangular, labeled, and, if applicable, filled out in blue.

In these instructions, all other example documents are labeled.
Day 1: Question Assessment/Technique/Observations/Reproducibility Discussion/Variables

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Question Assessment (SciTrek Lead) – 5 minutes
- Technique (SciTrek Lead) – 10 minutes
- Observation Discussion (SciTrek Lead) – 2 minutes
- Observations (SciTrek Volunteers) – 15 minutes
- Reproducibility Discussion (SciTrek Lead) – 8 minutes
- Variable Discussion (SciTrek Lead) – 2 minutes
- Variables (SciTrek Volunteers) – 13 minutes
- Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

- (4) Volunteer Boxes:
  - □ Student nametags
  - □ (7) Student notebooks
  - □ Volunteer instructions
  - □ Picture of experimental set-up
  - □ Volunteer lab coat
  - □ (2) Pencils
  - □ (2) Wet erase markers
  - □ Ruler
  - □ (7) Timers
  - □ (2) Wood ramp holders (13 cm tall)
  - □ (2) Green balls (27 cm circ., ~200 g)
  - □ Measuring tape (152 cm)
  - □ Measuring tape (300 cm)
  - □ Large binder clip

- Other Supplies:
  - □ (4) Large group notepads
  - □ (4) 6 ft x 2 ft carpet
  - □ Box with 4 electronic scales
  - □ (4) Ball stop boards (65 cm x 30 cm)
  - □ (4) Boards (50 cm x 30 cm) with shag carpet
  - □ (4) Boards (50 cm x 30 cm) with outdoor carpet
  - □ (4) Pieces of shag carpet (30 cm x 100 cm)

- Lead Box:
  - □ (3) Blank nametags
  - □ (3) Extra student notebooks
  - □ Lead instructions
  - □ Motion picture packet
  - □ Picture of experimental set-up
  - □ Lead lab coat
  - □ (25) Question Assessments
  - □ Time card
  - □ (2) Pencils
  - □ (2) Wet erase markers
  - □ (4) Markers (orange, blue, green, purple)
  - □ Ruler
  - □ (4) Timers
  - □ (2) Green balls (27 cm circ., ~200 g)
  - □ Measuring tape (152 cm)
  - □ Measuring tape (300 cm)
  - □ Large binder clip
TECHNIQUE
Timers

How to read a timer:
The diagram below shows what each number on a timer stands for:

\[
\begin{array}{c|c|c|c}
\text{Hour} & \text{Minute} & \text{Second} \\
\hline
1 & 2 & 3 \\
\end{array}
\]

Fraction of a Second

1. If 3:23:45 is seen on your timer how much time has passed?
   Hours: 3  Minutes: 23  Seconds: 45  Fraction of a Second: \( \frac{25}{60} \)

2. If 00:00:00 is seen on your timer how much time has passed?
   Hours: 0  Minutes: 0  Seconds: 0

How to set a timer:
1. If timer is off, push the blue button to turn it on.
2. If you do not see 00:00:00 then push the blue button again to reset the timer.
3. To start the timer push the yellow button.
4. To stop the timer push the yellow button again.
5. Record time to the nearest fraction of a second.
6. To reset to 00:00:00, push the blue button.
7. Repeat.

Practice recording the amount of time it takes to do the following activities:
1. How long does it take the SciTrek to unsnap/snap their lab coat? \( 2 \frac{3}{5} \) s
2. How long does it take the SciTrek to jump three times? \( 1 \frac{3}{5} \) s

OBSERVATIONS

Shag Carpet Run:
- Ball released from top of the ramp
- Time to hit the board: 1 \( \frac{3}{5} \) s, 1 \( \frac{3}{5} \) s, 1 \( \frac{3}{5} \) s
- Ball made a sound when it hit the board

Outdoor Carpet Run:
- Ball released from top of the ramp
- Time to hit the board: 1 \( \frac{5}{5} \) s, 1 \( \frac{5}{5} \) s
- Ball made a louder sound when it hit the board

Class Data Sheet

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Shag Carpet (s)</th>
<th>Outdoor Carpet (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab</td>
<td>( \frac{1}{10} )</td>
<td>( \frac{0}{10} )</td>
</tr>
<tr>
<td>1</td>
<td>1 ( \frac{3}{10} )</td>
<td>0 ( \frac{2}{1} )</td>
</tr>
<tr>
<td>2</td>
<td>1 ( \frac{3}{1} )</td>
<td>1 ( 1 )</td>
</tr>
<tr>
<td>3</td>
<td>1 ( \frac{3}{1} )</td>
<td>1 ( \frac{3}{1} )</td>
</tr>
<tr>
<td>4</td>
<td>1 ( \frac{3}{1} )</td>
<td>1 ( \frac{3}{1} )</td>
</tr>
</tbody>
</table>

Smallest --- Largest

Shag Carpet (s)

Outdoor Carpet (s)
**Preparation:**

**SciTrek Lead:**
1. Make sure volunteers are writing their name and group color on the whiteboard.
2. Make sure volunteers are passing out nametags.
3. Make sure volunteers are setting up for the initial observation. Details of how to do this are on a picture in the volunteer boxes.
4. If the classroom has a document camera, ask the teacher to use it for the Technique Activity (page 2, student notebook) and to share the class data (page 1, picture packet). If the classroom does not have a document camera, then tape the poster-size notebook page and class data chart to the front board during the Technique Activity and Observation Discussion.

**SciTrek Volunteers:**
1. On the front whiteboard in the classroom, write your name and the color of the group (orange, blue, green, or purple) you will be working with.
2. Pass out student nametags.
3. Assemble the experimental set-up (shown in picture below as well as in color in the experimental set-up picture in your group box) on a spot on the floor where ~five students can sit.
   a. Roll out the outdoor carpet.
   b. Place the piece of shag carpet so that it covers half of the run.
   c. Set up the outdoor carpet ramp in front of the outdoor carpet section of the run.
   d. Set up the shag carpet ramp in front of the shag carpet section of the run.
   e. Put the wood ramp holders under each of the ramps to give the ramps a slope.
   f. Make sure the wood ramp holders are as far under the ramps as they can go.
   g. Attach the 300 cm measuring tape (yellow) with the binder clip on the top of the shag carpet ramp and extend the measuring tape to the end of the run.
   h. Set the ball stop board (65 cm x 30 cm) at the 100 cm mark on the measuring tape.
   i. Set the timers, 152 cm measuring tape (white), scale, ruler, and one of the green balls on the set-up.
   j. Hide the second green ball in your lab coat pocket until the end of the observations.
4. Have notebooks and timers available to pass out.

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**Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>How will changing this variable affect ball motion?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball mass</td>
<td>Heavier balls will hit the board first because they will gain more speed as they travel down the ramp.</td>
</tr>
<tr>
<td>Ramp height</td>
<td>The taller the ramp height the faster the ball will hit the board because the ball will roll faster down the ramp.</td>
</tr>
<tr>
<td>Ball circumference</td>
<td>The bigger the ball circumference the faster the ball will hit the board because larger objects gain more speed as they roll down the ramp.</td>
</tr>
<tr>
<td>Ramp length</td>
<td>The longer the ramp length the more time the ball will take to hit the board because it has a longer distance to travel.</td>
</tr>
<tr>
<td>Ball material</td>
<td>Balls made out of rougher materials will take more time to hit the board because they will stick to the carpet more and travel slower.</td>
</tr>
</tbody>
</table>
**Introduction:**

*(2 minutes – Full Class – SciTrek Lead)*

If they have not done so already, have volunteers write their name and group color on the front whiteboard and then get student nametags out of their group boxes and walk around the room quietly setting each student’s nametag on their desk. After, they should assemble the experimental set-up.

For UCSB Lead:

“Hi, we are scientists from UCSB and we want to show you what we do as scientists. We will show you an experiment and then you can make observations, ask questions, and design your own experiment to help answer the class question. We want to show you that you can do science and have fun.”

For Teacher Lead:

“I have asked some scientists from UCSB to come and help us with a long-term science investigation. We will make observations, come up with a class question, and you will design your own experiment to help answer the class question.”

Allow the UCSB volunteers to introduce themselves and share their majors.

**Question Assessment:**

*(5 minutes – Full Class – SciTrek Lead)*

“Before we start with the module, we will determine how your ideas on testable questions are developing.” Pass out the Question Assessment and tell students to fill out their name, teacher’s name, and date at the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

Read the instructions to the students. Then read each of the questions and tell students to circle “testable” for questions that science can answer or “not testable” for questions that science cannot answer. When students are finished, collect the assessments and verify that the students’ names are on the papers.
**Technique:**
*(10 minutes – Full Class – SciTrek Lead)*

Have volunteer pass out a notebook to each student.

Have students fill out their name, teacher’s name, group color (color of their name on their nametag: orange, blue, green, or purple), and their volunteer’s name (volunteers’ names should be written on the board next to the group color they will be working with) on the front cover of their notebooks. If a student does not have a nametag, only have them fill out their name and teacher’s name on the cover of their notebook. They will be placed in a group when the class divides into groups for observations and they can fill out their group color and volunteer at that point.

Tell the class that for this module we are going to roll balls down ramps to try to answer the question, “What variables affect ball motion?” Ask students, “Why do you think scientists would investigate this question?” By the end of the conversation, make sure that students understand that if we can find patterns in ball motion, this means that motion is predictable, and we can predict future ball motion. Tell students that in order to do this, we will need to be able to measure the time it takes a ball to travel a certain distance.

Have students turn to page 2 in their notebooks and place a class notebook under the document camera. Tell students, “For this experiment it is very important that your measurements of time are precise so that we can tell exactly how long it takes the ball to hit a board at a given distance for each of your trials.”

Go over how to read the timer using the diagram. Tell students, “The first number, before the colon, tells the number of hours for which the timer has run.” Ask students, “How many hours did the top timer run?” Students should reply, “1 hour.” Tell students, “The next number, between the colon and the apostrophe, is the number of minutes for which the timer has run.” Ask students, “How many minutes did the top timer run?” Students should reply, “12 minutes.” Tell students, “The next number, between the apostrophe and the quote, is the number of seconds for which the timer has run.” Ask students, “How many seconds did the top timer run?” Students should reply, “23 seconds.” Tell students, “The last number (the small number) shows the parts of seconds.” Ask students “Do we know a way to record numbers that are a part of a whole?” Possible student response: we can record parts of whole numbers using fractions. Tell students that the parts of a second go up to 10. Ask students, “What should the bottom number, or the denominator, be for this fraction?” Students should reply, “The denominator will be 10.” Tell students, “The numerator, or top number of the fraction, will be the small number we see on our timer.” Ask students, “How should we record the parts of seconds for the top timer?” Possible student response: the 7 parts on the timer should be put into a fraction over 10, giving $\frac{7}{10}$. Tell students they will now fill out questions 1 and 2 on their own and then go over it as a class.
Have students go through numbers 1 and 2 on their own. Walk around to help the students who are struggling. After approximately two minutes, bring the class back together to go over the answers.

Go over the answers for questions 1 and 2. Have a student tell you their answer and have the class compare their own answers using thumbs up/thumbs down. After the class agrees on the correct answer, record it in the class notebook. Record the following:

1. 3 hours, 0 minutes, and 45\frac{3}{10} seconds
2. 0 hours, 1 minute, and 7\frac{2}{10} seconds

Tell students, “Now that you know how to read a timer, you must also learn how to operate a timer.” Go through the steps listed in their notebook. While you are going through the steps, have the SciTrek volunteers pass out a timer to each student.

1) If the timer is off, push the blue button to turn it on.
2) If you do not see 00:00:00, push the blue button again to reset the timer.
3) To start the timer, push the yellow button.
4) To stop the timer, push the yellow button again.
5) Record the time to the nearest tenth of a second. Example: 0:00’12” would be recorded as 12\frac{8}{10} s.
6) To reset to 00:00:00, push the blue button.
7) Repeat.

Let students practice starting, stopping, and clearing the timer.

Tell students that they will now time two different activities. For the next two activities, have a volunteer time the processes with the students so that students can have a number to compare their time to. For the first activity, they will record the amount of time it takes someone (either you or a volunteer) to unsnap and snap their lab coat. Count them down to the start by saying “3…2…1…Go.” They should start their timers when you say go. They should stop the timer when the last snap is done. Try to make this
take approximately 15 seconds. Have each student write down the time they recorded in their own notebook. Have the students check their time with the volunteer’s time. Students should be able to get within one second of the volunteer’s time.

For the second practice activity, the students will record how long it takes someone (either you or a volunteer) to jump three times. Warn them that you are a good jumper so this will go very quickly, and they need to pay close attention. They will start timing when you say go and they will stop timing the second your feet hit the ground on the third jump. Ask students, “If you cannot see my feet hit the ground when I am jumping, will you still be able to tell when I have hit the ground after my third jump?” Possible student response: yes, we will be able to hear your feet hit the ground. Make sure that all students have reset their timers using the blue button. Remind students that the yellow button is used to start and stop the timer. Count them down to the start by saying “3…2…1…Go.” On go, start jumping. Have each student write down the time they recorded in their own notebook. Have the students check their time with the volunteer’s time. Students should be able to get within $\frac{4}{10}$ of a second of the volunteer’s time.

Tell students that now they know how to use a timer, they will be able to use this skill to help them make observations.

**Observation Discussion:**

*(2 minutes – Full Class – SciTrek Lead)*

Tell the students that scientists make many observations. Ask the class, “What is an observation? What are the types of things that you can record for an observation?” If they have trouble, show them an object and let them make some observations. Turn these specific observations into general features of an observation. Examples of possible general observations are: color, texture, size, weight, temperature, material, etc. Lead students to understand that an observation is a description using your five senses.

Tell students, “In this experiment we are going to make observations of a ball rolling down two runs made out of different materials. These observations will help us determine if run materials affect ball motion.”

Tell the class they will now get in their groups and make observations. Tell each colored group where to go and to bring their timer and notebook.

If a student does not have a nametag, identify the group with the least number of students in it and write the student’s name on one of the extra nametags that are in the lead box using that color of marker.

**Observations:**

*(15 minutes – Groups – SciTrek Volunteers)*

Once the students come over to your group, have them sit in boy/girl fashion, collect their timers and notebooks, and put them in your group box. Students will not need their notebooks until the next session. Put out three timers and verify that the floor is set up as described in the Set-Up Section.

As a group, have the students generate observations about the experimental set-up before you start rolling the ball down the ramp. This should take you no longer than 10 minutes. Observations should be recorded on page 1 of the group notepad. Make sure to record the following observations about the experimental set-up: ramp height (13 cm), ramp length (50 cm), the run distance (distance to the ball stop board) (100 cm), ball mass (~200 g), and ball circumference (27 cm). Use the scale to measure the mass of the ball.
Pass out a timer to three students. MAKE SURE THAT ONLY 3 STUDENTS ARE TIMING AND THAT YOU ONLY DO THE TRIAL ONCE. Tell the other students that they will get a chance to measure the time the ball takes to hit the board for the next trial. Put the ball at the top of the shag carpet ramp, against the ramp holder. Tell students to stop the timer when they both see and hear the ball hit the board. Count down by saying “3…2…1…Go” and release the ball. On the group notepad, ONLY record the three times the students measure as well as other observations about the shag carpet. Remember to record the partial seconds in a fraction of 10. Do not have them put the times in order or find the median. This should take no longer than 2 minutes.

Repeat the process for the outdoor carpet ramp, having three different students time. Put the ball at the top of the ramp and count down by saying “3...2...1...Go,” and release the ball. Again, on the group notepad, record the three times to the nearest tenth of a second in fraction form, as well as other observations about the outdoor carpet. This should take no longer than 2 minutes.

Ask students, “What was different about the two runs?” Possible student response: it took the ball longer to hit the board with shag carpet than outdoor carpet. Ask students, “Is there another way that we could prove that the ball takes longer to reach the board when the ball is rolled on shag carpet instead of outdoor carpet?” Make sure by the end of the conversation that students generate the idea of racing two balls: one on the shag carpet ramp and one on the outdoor carpet ramp. Once students have generated this idea, bring out the other green ball. Place both balls at the top of the ramp and release them at the same time.

The lead will come around to write down each group’s median times on a class data sheet. Do not have students in your group find the median for each trial.

If there is additional time, have students summarize what they saw and learned. Make sure that students know that for this experiment their changing variable was run material and that they know how this variable affected ball motion.

An example filled out initial observations is shown below.
Reproducibility Discussion:
(8 minutes – Full Class – SciTrek Lead)

Have the students look at the class data sheet (page 1, picture packet) seen below. Ask students, “Did every group get the same results?” They should reply, “No.” Ask students, “Did all of the groups run the same experiment?” Have students explain the experiment they carried out, as well as what they measured in their groups. They should all realize that they did the same experiment. Ask students, “Why did groups get different times if they all did the same experiment?” Some possible responses might be: the ball did not roll straight, a ball wasn’t released from exactly the top of the ramp, or different students might have stopped the timer at different times.

![Class Data Sheet]

Tell students that scientists often perform multiple trials of the same experiment to try to account for any error or inconsistency in their data. However, when they present their data, they like to report one number instead of all the numbers they measured.

Ask the class, “What number would you pick if you had to pick one data point to represent the time it took the ball to hit the board on both outdoor and shag carpet?” Since students used the median number for representing an entire data set in their last SciTrek module, they will most likely give this example.

Tell the students that they are going to find the median number in each set of numbers. Starting with the run on the shag carpet, have the students rearrange the numbers so that they are in increasing order. Then, have the students identify the middle number. With both the lab data and the students’ data, there should be five numbers, which will give one middle number. Repeat this process for the trial on the outdoor carpet.

Ask students, “What did you learn about ball motion from this experiment?” Students should be able to tell you that the run material affects ball motion and that the smoother the surface, the shorter the time it takes for the ball to hit the board (faster the ball travels). Ask students, “Can you predict one surface
that would cause the ball to hit the board in a shorter time than outdoor carpet and one surface that would cause a longer time than shag carpet?" Possible student response: smooth plastic would cause a shorter time than outdoor carpet and long grass would cause a longer time than shag carpet.

**Variable Discussion:**

*(2 minutes – Full Class – SciTrek Lead)*

Tell students they are now going to think about other variables they could test to help them better understand ball motion.

Ask students the following questions:

- What does the word “variable” mean to a scientist? (variables are the parts of the experiment that you can change)
- What was the changing variable in the experiment that we just did? (ramp material)
- Do you think that there are multiple variables that will affect ball motion? (multiple variables might affect ball motion)
- Explain that this is why we will need to work as a class to answer the class question: “What variables affect ball motion?”

Tell the class that they are going to think about variables in the experiment that they could change to help us answer the class question. In addition to generating variables, they should think about how/why these variables might affect the outcome of the experiment. Ask the class, “What do you think is a variable that might affect the ball motion?” Then, have them tell you how/why they think that variable would affect ball motion. Probe them on how they would design an experiment to test if this variable affected the ball motion. Finally, have the students make a prediction of the results for the experiment they proposed. Remind students that predictions can be wrong, and we will not know the correct answers until we carry out the experiment.

Ex:  

**Variable:** ramp height  

*Why might this variable affect ball motion?* Higher ramps might cause the ball to move faster down the ramp and hit the board in less time.  

*How would you test this variable?* Do several trials in which you release the ball from multiple different ramp heights.  

*Prediction:* The taller the ramp the shorter the time for the ball to hit the board.

Tell students they will now generate more variables and analyze them in their groups.

**Variables:**

*(13 minutes – Groups – SciTrek Volunteers)*

As a group, generate a variable and make a prediction about how it will affect ball motion. Encourage and challenge students to explain why they think their prediction is correct and how this variable will affect ball motion. Record both the variable and the prediction on the group notepad. After each prediction, survey your group and write down how many students agree with the prediction and how many disagree. If there is extra time, go around the table a second time. An example filled out variables is shown below. Students do not need to record the variables or predictions into their notebooks.

Prepare one student to share a variable and why they think it will affect ball motion during the class discussion.
**Wrap-Up:**

*(3 minutes – Full Class – SciTrek Lead)*

Have one student from each group share a variable that they generated and how/why they think it will affect ball motion. Make sure that students tell you their predictions about how different values of that variable will affect ball motion.

Tell the students that during the next session they will design an experiment to answer the class question: What variables affect ball motion?, which will help them learn about ball motion.

**Clean-Up:**

1. Collect notebooks with attached nametags.
2. Place all materials in your group box and bring materials back to UCSB.
Day 2: Question Activity/Questions/Materials Page/Experimental Set-Up

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Question Activity (SciTrek Lead) – 20 minutes
- Question Discussion (SciTrek Lead) – 3 minutes
- Testable Questions (SciTrek Volunteers) – 8 minutes
- Question Discussion (SciTrek Lead) – 3 minutes
- Non-Testable Questions (SciTrek Volunteers) – 4 minutes
- Question/Experimental Set-Up Discussion (SciTrek Lead) – 3 minutes
- Question (SciTrek Volunteers) – 4 minutes
- Materials Page (SciTrek Volunteers) – 5 minutes
- Experimental Set-Up (SciTrek Volunteers) – 5 minutes
- Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

(4) Volunteer Boxes:
- □ Student nametags
- □ Student notebooks
- □ Volunteer instructions
- □ Volunteer lab coat
- □ (5) Materials pages (one for each possible variable)
- □ (2) Pencils
- □ (2) Wet erase markers

Other Supplies:
- □ (4) Large group notepads
- □ Board (45cm × 30cm) with outdoor carpet
- □ Board (60cm × 30cm) with outdoor carpet

Lead Box:
- □ (3) Blank nametags
- □ (3) Extra student notebooks
- □ Lead instructions
- □ Motion picture packet
- □ Lead lab coat
- □ (5) Materials pages (one for each possible variable)
- □ Time card
- □ (2) Pencils
- □ (2) Wet erase markers
- □ (4) Marker (orange, blue, green, purple)
- □ Purple ball (27 cm circ., ~360 g)
- □ Red ball (27 cm circ., ~55 g)
- □ Green ball (30 cm circ., ~200 g)
- □ Green ball (21 cm circ., ~200 g)
SCIENTIFIC PRACTICES  
Testable Questions  
Circle TESTABLE if the question can be tested by science. Circle NOT TESTABLE if the question cannot be tested by science.

1. How much does an astronaut’s suit weigh?  
   Testable  
2. Do dogs like Astronaut ice cream?  
   Not Testable  
3. Is Venus prettier than Saturn?  
   Not Testable  
4. How many moons orbit around Jupiter?  
   Not Testable  
5. Which planet, other than Earth, is the most habitable?  
   Not Testable  
6. How fast does Luke Skywalker fly his spaceship?  
   Can’t measure data  
7. How many telescopes are there in the United States?  
   Not Testable  
8. Is the space shuttle big?  
   Not Testable  
9. Is studying the solar system valuable?  
   Not Testable  
10. What color light do stars give off?  
    Testable  

Circles are your initial thought and boxes are the correct answer.

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SCIENTIFIC QUESTIONS  
If we change the **ball mass**, what will happen to the **time it takes to hit the board**?

- If the ball circumference is changed, how long will it take the ball to hit the board?
- How long will it take the ball to hit the board if I change the ramp height?

---

NON-SCIENTIFIC QUESTIONS  
- Does the ball like rolling down the ramp?
- Will Batman’s car go down the ramp fast?
- Is the ramp big?
- What kind of ball is better, a big one or a small one?
Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. You will run four trials.
3. For each trial, you must measure the time the ball takes to hit the board.

Changing Variable (Independent Variable): ball mass

Discuss with your group how you think your changing variable will affect ball motion.

**QUESTION**

Question our group will investigate:

- If we change the ball mass, what will happen to the time the ball takes to hit the board?

Fill out the materials page with your SciTrek volunteer before moving onto the experimental set up.

**EXPERIMENTAL SET-UP**

Determine the values of your changing variable (e.g., ball mass) from the materials page and write the values (e.g., 15 g) for your 4 trials under each set up.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Ball mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>~265 g</td>
</tr>
<tr>
<td>B</td>
<td>~165 g</td>
</tr>
<tr>
<td>C</td>
<td>~55 g</td>
</tr>
<tr>
<td>D</td>
<td>~360 g</td>
</tr>
</tbody>
</table>

Controls (variables you will hold constant):

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Ball</th>
<th>Ramp length</th>
<th>Ramp height</th>
<th>Run material</th>
<th>Run length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ball</td>
<td>50 cm</td>
<td>22 cm</td>
<td>indoor carpet</td>
<td>200 cm</td>
</tr>
</tbody>
</table>

Predictions:

I predict that when the **ball mass** is ~360 g, the ball will hit the board in the least amount of time.

I predict that when the **ball mass** is ~55 g, the ball will hit the board in the least amount of time.
Preparation:

SciTrek Lead:
1. Make sure volunteers are setting out notebooks.
2. If the classroom has a document camera, ask the teacher to use it for the Question Activity (page 3, student notebook). If the classroom does not have a document camera, then tape the example poster-size notebook pages to the front board.

SciTrek Volunteers:
1. Set out notebooks/nametag.

Note: If students are not in the classroom before SciTrek starts, notebooks should be set out where students should sit when they come into the classroom. If students are in the classroom before SciTrek starts, notebooks should be set out where students should sit during the module; they will move to these spots after the introduction.

Introduction:
(2 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.

Ask students, “What did we do and learn during our last meeting?” Possible student response: we did an experiment in which we changed the run material and timed how long it took a ball to roll down two different runs and hit a board. One run was made from outdoor carpet and one was made from shag carpet. We learned that the outdoor carpet (which was smoother) caused the ball to hit the board in less time than the shag carpet. Ask the class, “What is the class question we will be investigating?” Students should reply, “What variables affect ball motion?”

Ask students, “Why might scientists study ball motion?” Students should explain that studying ball motion will help them predict what will happen to an object that is in motion. For instance, the first experiment showed that the ball took less time to hit the board on a smooth surface than on a bumpy surface, which suggests that other objects in motion will travel faster on smooth surfaces than on bumpy surfaces.

Tell students that one way scientists answer questions is by performing experiments; today they are going to generate testable questions about the ramp set-up, after which they will be able to pick a question and design an experiment to answer that question. First, we are going to look at a list of questions and decide whether each question is testable by science.

Question Activity:
(20 minutes – Full Class – SciTrek Lead)

Ask students, “What type of questions can be tested by science?” You should get answers that revolve around the idea that science can test things that are measurable, observable, or countable. Write on the board:

Testable Questions:
- Measurable
- Observable
- Countable
Ask students, “What type of questions cannot be tested by science?” You should get the following two groups of untestable questions:

1) Questions in which the data cannot be acquired.
   • Data cannot be acquired on objects or characters that do not exist. Ex: How many fingers do fairies have? Since we cannot catch fairies, we would not be able to answer this question.

2) Questions that are not well defined or are opinions.
   • Opinion questions contain opinion words such as prettier, nicest, better, etc. Ex: Which are prettier, lilies or daisies?
   • Not well defined questions contain words such as affected, react, etc. Ex: Do squirrels react to dogs?
   • Not well defined questions can contain semi-measurable words such as big, wide, heavy, etc. Ex: Is the Golden Gate Bridge wide? The problem with this question is you do not know how the questioner defines the word wide. A scientist could answer this question “yes” if they were comparing the Golden Gate Bridge to a typical overpass bridge while another scientist could answer the question “no” because they were comparing the Golden Gate Bridge to the Pacific Ocean.

Write on the board:

Not Testable Questions:
- Can’t acquire data
- Not well defined/Opinion

Tell the students to turn to page 3 of their notebooks, while you place the class notebook under the document camera and turn to page 3. Read the directions aloud to the class. Read the first question to students, then give them approximately 15 seconds to circle the answer. Have students share what they think is the correct answer and why. Have the class vote using thumbs up/thumbs down if they agree/disagree with the student’s reasoning. After the class has come to a consensus, tell students that they will now box the correct answer. Remind them not to erase their original answer because then they will be able to see which concepts/categories they are struggling with. Box the correct answer on the class notebook for students to copy.

If the question is testable, have students tell you what they would measure/count/observe to find the answer to the question. Then, write what they would do next to the question (measure, count, or observe). If the question is not testable, first, have the students identify the part of the question that is not testable and why (if applicable, underline the non-testable word in the question). Write why the question is not testable next to the question (can’t acquire data or not well defined). Second, have the students propose a related question that is testable.
Below are the answers to 1-10 on page 3 in detail.

**Number 1:** How much does an astronaut’s suit weigh?

*Testable (Easy to Test-Measurement)*

Is this question testable?
Yes.

What could be measured/observed to answer this question?
Measure the weight of an astronaut’s suit.

**Number 2:** Do dogs like Astronaut Ice Cream?

*Not Testable (Not Well Defined/Opinion-Contains the Word Like)*

Is this question testable?
No.

Why is the question not testable?
The word “like” is an opinion and it is impossible to measure if a dog likes Astronaut Ice Cream. (A dog could eat the Astronaut Ice Cream because it likes the ice cream or because it is hungry and needs nutrients.)

How can we revise this question to make it testable?
Which food do dogs eat first, Astronaut Ice Cream or steak?

**Number 3:** Is Venus prettier than Saturn?

*Not Testable (Not Well Defined/Opinion-Comparison)*

Is this question testable?
No.

Why is the question not testable?
The word “prettier” is not well defined/opinion. Many people disagree about which objects are prettier.

How can we revise this question to make it testable?
Which planet has more rings, Venus or Saturn?
**Number 4:** How many moons orbit Jupiter?

*Testable (Easy to Test-Counting)*

Is this question testable?

Yes.

What could be measured/observed to answer this question?

Count the number of moons that orbit Jupiter.

**Number 5:** Which planet, other than Earth, is the most habitable?

*Not Testable (Not Well Defined/Opinion)*

Is this question testable?

No.

Why is the question not testable?

The word “habitable” is not well defined/opinion. (Habitable could mean that the planet has water or could mean that the planet has the same temperature range as Earth.)

How can we revise this question to make it testable?

What is the hottest temperature recorded on Venus in 2012?

**Number 6:** How fast does Luke Skywalker fly his spaceship?

*Not Testable (Can’t Acquire Data)*

Is this question testable?

No.

Why is the question not testable?

We will not be able to acquire data on Luke Skywalker because he is a fictional character.

How can we revise this question to make it testable?

What is the speed of an average space shuttle?

**Number 7:** How many telescopes are there in the United States?

*Testable (Hard to Test)*

Is this question testable?

Yes. (Even though this question is hard to test, it still can be tested.)

What could be measured/observed to answer this question?

Count the number of telescopes in the United States.

**Number 8:** Is the space shuttle big?

*Not Testable (Not Well Defined/Opinion-Semi Measurable)*

Is this question testable?

No.

Why is the question not testable?

The word “big” is not well defined in this context. (The space shuttle is big compared to people, but small compared to the Earth.)

How can we revise this question to make it testable?

Which is taller, the space shuttle or a person? or What is the size of the space shuttle?
Number 9: Is studying the solar system valuable?

Not Testable (Not Well Defined/Opinion-Students Think the Answer is Yes)

Is this question testable?
No.

Why is the question not testable?
The word “valuable” is not well defined/opinion. (Valuable could mean that studying the solar system can increase their knowledge about space or could mean that you could use this knowledge to make money.) Note: this question is particularly hard for students because they think the answer to the question is yes. Instead of thinking about if the question is testable or not, they try to argue the answer is “yes.”

How can we revise this question to make it testable?
Does studying the solar system increase the number of planets people can name?

Number 10: What color light do stars give off?

Testable (Easy to Test-Observation)

Is this question testable?
Yes.

What could be measured/observed to answer this question?
Observe stars and determine the color light they give off.

Question Discussion:
(3 minutes – Full Class – SciTrek Lead)

Tell students that they are going to generate their own testable questions about the ramp set-up that they used last session. They will be able to use the variables that they generated last time to help them with their questions. Make sure that students understand that scientists define a variable as something that can be changed in an experiment to learn something about the system. Have a few students share variables that they generated last class session.

Hold up one of the group notepads with the following sentence frame:

If we change the __________________, what will happen to the ____________________________?

variable what you are measuring/observing

Tell students that they can insert a variable into blank 1 and something that they can measure/observe into blank 2 to generate a testable question.

As a class, come up with one question that fits this sentence frame.

Ex: “If we change the ramp height, what will happen to the time it takes the ball to hit the board?”

Tell the students that they will now work together to generate as many testable questions about the ramp set-up as possible.

Testable Questions:
(8 minutes – Groups – SciTrek Volunteers)

As a group, have the students come up with a question in the form: “If we change the ____________, what will happen to the ____________?” After they have generated one question in this form, they may generate other questions in any form they want. If students do not generate testable questions in the form provided, try to have students identify what data they would need to collect to answer their question. Example: What is the longest ramp in the world? The data that would need to be collected is the measurements of the lengths of all the ramps in the world. If students are having trouble generating questions, have them review the variables that they generated during the previous meeting.
Prepare one student to share a question with the class. An example filled out Scientific Question is shown below.

![Image of a filled out scientific question]

**Question Discussion:**
*(3 minutes – Full Class – SciTrek Lead)*

Have one student from each group share one of their testable questions with the class. After a group’s question is presented, ask the rest of the class, “Is the question testable and, if so, what data would the group need to collect to answer the question?”

Tell students there are many questions that science cannot answer. Ask students, “Do you know the types of questions science cannot answer?” They should be able to generate the following two categories of questions:

- Category 1: Can’t acquire data
- Category 2: Not well defined/opinion

Ask students, “Can someone give an example question about the ramp set-up that science cannot answer?”

Ex: Category 1 Question: Does the ball roll down the ramp at the same speed in Neverland?
Ex: Category 2 Questions: Does the ball like rolling down the ramp? or Is learning about ball motion important?

Tell students that they are now going to generate questions that science cannot answer about the ramp set-up with their group.

**Non-Testable Questions:**
*(4 minutes – Groups – SciTrek Volunteers)*

Have the students generate a list of questions that science cannot answer and record them on the group notepad. Encourage students to generate questions that are in both of the non-testable categories. If they are struggling, have them turn to the question activity and look at the questions that are not testable. Ask
students, “Why is this question not testable?” Then have them use it as a model to generate a question about the ramp set-up.

Prepare one student to share one of their questions with the class. An example filled out Non-Scientific Questions is shown below.

![Non-Scientific Questions](image)

**Question/Experimental Set-Up Discussion:**

*(3 minutes – Full Class – SciTrek Lead)*

Have each group share one question that they generated that science cannot answer. After a group’s question is presented, ask the rest of the class, “Is the question testable and, if not, why?”

Tell students that they are going to design an experiment to determine how one variable affects ball motion. First, they will pick their changing variable and record it in their notebooks. Tell students that their options for their changing variable are ramp height, ramp length, ball mass, ball circumference, and run length, and show students the example materials as they are being discussed. Second, they will discuss why they think this variable will affect ball motion and determine their experimental question. Third, they will use the materials page to determine the values of their changing variable and controls. Fourth, they will determine their experimental set-up. Ask students how scientists define controls. By the end of the conversation make sure students understand that controls are variables that could have changed but are kept constant for their experiment. Tell students that they need to keep a few things in mind when they are going through this process.

**Experimental Considerations:**

1. You will only have access to the materials on the materials page.
2. You will run four trials.
3. For each trial you must measure the time the ball travels (time from ball release to ball hitting the board) three times.
Question:
(4 minutes – Groups – SciTrek Volunteers)

Have students turn to page 4 of their notebooks. Then have them decide (by voting) what changing variable they want to explore for their experiment. If there is a tie, then the volunteer will make the deciding vote. It is best if groups have different changing variables. The lead will help coordinate between groups to ensure there is a variety of changing variables.

As a group, discuss why/how they think their changing variable will affect ball motion. Record their thoughts on the group notepad; students will not write this in their notebooks.

Use their changing variable to generate the question that the group is going to investigate. Write the question in the group notepad, and have students copy it into their notebooks. An example filled out question is shown below.

Select a student to read the group question during the wrap-up.

Materials Page:
(5 minutes – Groups – SciTrek Volunteers)

Get the materials page (shown below) that corresponds to the changing variable that your group selected. Have students use the materials page to determine the values for their changing variable and controls. When selecting the values of the changing variable, ask students, “Do you think a wide or a narrow range of values would help you more effectively answer your question?” Make sure they understand that a wide range of values will make it easier for them to see a difference in their results. For each changing variable value, write the trial letter (A, B, C, D) next to the value.
For controls in which students can pick more than one value (run length, ramp height, and ball mass), have students discuss if the value that they select for their control would make it easier or harder to answer their question. For example, if students chose a run length of 50 cm, ask them how this would affect answering their question. This might get them to realize that a 50 cm run would have a very short time, resulting in most of the times being approximately the same for all of the trials. If they decide a different control value is better, allow them to switch control values.

Make sure that your group checked off all of the materials that they will need from the materials page and that your group color is written on the top of the page. Make sure that students have picked run lengths/ramp heights that are within the limitations set on the materials page. Examples of all materials pages are shown below.

**Experimental Set-Up:**
*(5 minutes – Groups – SciTrek Volunteers)*

Turn to page 7 of the group notepad while students turn to page 5 in their notebooks. Ask your group, “What did we decide was going to be the changing variable and what values of the changing variable did we choose for each trial?” Record these on the group notepad. After, have students copy the changing variable and its values into their notebooks.
Ask your group, “What controls and values did we select?” Write the control on the left side of the slash and the value of the control on the right side of the slash (Ex: run material / outdoor carpet). In addition, have students copy these into their notebooks. An example filled out experimental set-up is shown below.

Once the experimental set-up is complete, have students predict what will happen in the experiment and fill in the sentence frames on page 5. The prediction sentences can be different in each student’s notebook.

If you have additional time, have your group summarize the experiment that they are going to run and what they are hoping to learn from the experiment.

Wrap-Up:
(3 minutes – Full Class - SciTrek Lead)

Have one student from each group share the question that they will investigate. Tell students that during the next session they will start their experiment. Tell students that all of their experiments will help us answer the class question: What variables affect ball motion?

Clean-Up:

1. Collect notebooks with attach nametag.
2. Place material in your group box and bring materials back to UCSB.
Day 3: Technique/Procedure/Results Table/Experiment

Schedule:

- Introduction (SciTrek Lead) – 3 minutes
- Technique (SciTrek Lead) – 7 minutes
- Procedure (SciTrek Volunteers) – 18 minutes
- Results Table (SciTrek Volunteers) – 5 minutes
- Experiment (SciTrek Volunteers) – 25 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(4) Volunteer Boxes:
- Student nametags
- Student notebooks
- Volunteer instructions
- Volunteer lab coat
- (2) Pencils
- (2) Wet erase markers
- Notepad
- Measuring tape (152 cm)
- Measuring tape (300 cm)
- Ruler
- (3) Timers
- Requested wood ramp holder or lab jack
- Requested ball(s)
- Large binder clip

Other Supplies:
- (4) Large group notepads
- Requested ramps lengths
- (3) Timers
- Ball stop boards 65 cm x 30 cm
- Box with 4 electronic scales
- (4) 6 ft x 2 ft outdoor carpet

Lead Box:
- (3) Extra student notebooks
- Lead instructions
- Motion picture packet
- Lead lab coat
- Time card
- (2) Pencils
- (2) Wet erase markers
- Notepad
- Measuring tape (152 cm)
- Measuring tape (300 cm)
- Ruler
- (4) Timers
- Wood ramp holder (13 cm tall)
- Wood ramp holder (22 cm tall)
- Yellow ball (27 cm circ., ~165 g)
- Green ball (27 cm circ., ~200 g)
- Large binder clip
Notebook Pages and Notepad Pages:

**TECHNIQUE**

**Median**

When running multiple trials in an experiment it is necessary to find one number to represent all of the data. The middle number, also known as the median number, is sometimes used to represent all the data. To find the median, first place all of the numbers from each trial in increasing order, second circle the middle number.

<table>
<thead>
<tr>
<th>Ball Material</th>
<th>Time Ball Travels (s) (in increasing order)</th>
<th>Median (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styrofoam Ball</td>
<td>5(\frac{1}{8}), 6(\frac{1}{4}), 6(\frac{1}{8})</td>
<td>6(\frac{1}{4})</td>
</tr>
<tr>
<td>Metal Ball</td>
<td>1(\frac{3}{4}), 1(\frac{1}{2}), 1(\frac{1}{8}), 2(\frac{1}{8})</td>
<td>1(\frac{1}{2})</td>
</tr>
<tr>
<td>Wooden Ball</td>
<td>2(\frac{1}{2}), 2(\frac{1}{8}), 2(\frac{1}{4})</td>
<td>2(\frac{1}{4})</td>
</tr>
<tr>
<td>Plastic Ball</td>
<td>4(\frac{5}{8}), 4(\frac{1}{2}), 5(\frac{1}{4})</td>
<td>4(\frac{1}{2})</td>
</tr>
<tr>
<td>Velcro Ball</td>
<td>3(\frac{5}{8}), 3(\frac{1}{2}), 3(\frac{1}{8}), 3(\frac{1}{4}), 4(\frac{1}{16})</td>
<td>3(\frac{1}{2})</td>
</tr>
</tbody>
</table>

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**PROCEDURE**

1. Roll out outdoor carpet.

2. Set up ramp that is 50 cm long and 22 cm high.

3. Get balls that have a circumference of 21 cm and masses of A) 265 g, B) 165 g, C) 55 g, D) 360 g.

4. Roll balls 200 cm and time.

5. Repeat 2 more times.

6. Find median number for each trial.
**Preparation:**

**SciTrek Lead:**
1. Make sure volunteers are setting out notebooks.
2. Make sure volunteers are setting materials that they will use with their group on the floor.
3. If the classroom has a document camera, ask the teacher to use it for the Technique Activity (page 6, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook page to the front board.

**SciTrek Volunteers:**
1. Set out notebooks/nametags.
2. Get materials that your group requested and place them in a pile on the floor where they will be doing their experiment but do not set them up.

**Note:** If students are not in the classroom before SciTrek starts, notebooks should be set out where students should sit when they come into the classroom. If students are in the classroom before SciTrek starts, notebooks should be set out where students should sit during the module; they will move to these spots after the introduction.

**Introduction:**
(3 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.
Ask the class, “What is the class question we are investigating?” Students should reply, “What variables affect ball motion?” Ask students, “What have we already learned about ball motion?” Possible student response: we learned that the smoother the run material the shorter the time it takes for the ball to hit the board. Remind students that last time they picked another variable that they are going to explore today. Ask students, “Are you going to run one or multiple trials?” They should reply, “Multiple trials.” Ask students, “If you have multiple numbers for each trial, what number will you use for the graph?” Students should reply, “The middle number, which is called the median.” Ask students, “Why is the median the best option to graph?” Possible student response: the median is a good representation of the data. Tell students that we will practice finding the median from other scientists’ data.

**Technique:**

*(7 minutes – Full Class – SciTrek Lead)*

Have students turn to page 6 in their notebooks while you do the same things to the class notebook under the document camera. Tell students, “To find the median, you need to arrange the numbers in increasing order. Once the numbers are arranged in order, the number in the middle is the median number, which you should identify by circling.” Go over how to find the median in the first two examples and then have the students work on the rest by themselves. After students have finished, go over the answers. An example of a student notebook page can be found below.

Tell students they will use this technique of finding the median when they perform their experiment.

Tell students that before they can carry out their experiment, they need to write a procedure. Ask the class, “What is a procedure?” Lead students to understand that it is a set of steps to conduct an experiment. Tell them once they have determined their procedure, they will fill out their results table and carry out their experiment.
**Procedure:**
*(18 minutes – Groups – SciTrek Volunteers)*

Ask students, “What did you pick for the changing variable and what do you think we will learn from the experiment?”

Tell students they will now generate a procedure for their experiment. Ask students, “What is a procedure?” Students should reply, “A set of steps to conduct an experiment.” Then, help students generate a procedure. Keep the procedure as brief as possible while still including the important information (control values, changing variable values, and what data they will collect). An example step if ball mass is the changing variable would be: “Get balls with a 27 cm circumference and masses of A) 250 g, B) 150 g, C) 50 g, and D) 350 g.” Have students dictate the procedure to you while you transcribe it onto the group notepad. As each step is complete, have students copy it from the group notepad into their notebooks. Make sure that you do not continue on to the next step until each student has completed writing that step. An example filled in procedure is shown below.

![Example Procedure](image)

**Results Table:**
*(5 minutes – Groups – SciTrek Volunteers)*

Fill out the variables section of the results table while students fill out the same section in their notebooks. When writing the values, make sure that for controls, they only write the value of the control in the trial A box and then draw an arrow through the remaining trials’ boxes; for the changing variable, they write the value in each trial’s box. An example filled out results table is shown in the Experiment Section.
**Experiment:**

(25 minutes – Groups – SciTrek Volunteers)

Once students have completed the variables section of their results table, have students move to their materials on the floor. Volunteers will fill out all data on the group notepad and students’ notebooks will be left at the tables during the experiment. Once experiments are completed, students will return to the tables and copy the data into their own notebooks.

Help students set up and complete their experiment. For each trial, your group will roll the ball three times. For each roll, there will be three students timing the ball. This will give you nine total times for each trial. Record the data that the students collect on a paper notepad (found in your box). Then, have the students tell you how to arrange the numbers from smallest to largest and copy them into the group notepad (see an example below). For each ball roll, have the students identify the median from your recorded numbers. This should be done before the ball is rolled again. The median number is the only number the students will record in their notebooks. On the group notepad, each trial will have a total of nine recorded times. The student notebooks will have three numbers recorded for each trial. Remember to record time to the nearest fraction of a second (Ex: $1 \frac{7}{10}$ s). Once all trials are completed and all data has been recorded, bring students back to their desks and have students copy the data into their notebooks.

When the students are finished copying the group data into their notebooks, have students put the times for trial A in ascending order and determine the median number for that trial. Then have students work independently to find the median number for the rest of the trials. After students are finished, go over the median numbers as a group and record the numbers on the group notepad. An example filled out result table is shown below.

If there is additional time, have students explain to you how they set up for their experiment and what they learned from their experiment. Try to have students explain this without looking at their notebooks.
Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell students that during the next session they will analyze their data by making a graph as well as a poster, which they will use to present their findings to the class. These posters will help us learn about what variables affect ball motion.

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place material sin your group box and bring materials back to UCSB.

Day 4: Graph/Results Summary/Poster Making

Schedule:

Introduction (SciTrek Lead) – 2 minutes  
Graph (SciTrek Volunteers) – 10 minutes  
Results Summary (SciTrek Volunteers) – 10 minutes  
Poster Making (SciTrek Volunteers) – 33 minutes  
Wrap-Up (SciTrek Lead) – 5 minutes

Materials:

(4) Volunteer Boxes:

□ Student nametags  
□ Student notebooks  
□ Volunteer instructions  
□ Volunteer lab coat  
□ Poster diagram  
□ Appropriate sticker for how to present graph (changing ball or ramp)

(8) Partial graph pieces  
(2) Pencils  
(5) Paperclips  
(2) Wet erase markers  
Highlighter  
Scissors  
(2) Glues  
Scotch tape  
Poster Parts packs (Scientists’ names, question, experimental set-up, procedure, results table, results graph, results summary, “I acted like a scientist when,”(6) Picture spaces)

Other Supplies:

□ (4) Large group notepads  
□ Poster paper tube

Lead Box:

□ (3) Extra student notebooks  
□ Lead instructions  
□ Motion picture packet  
□ Poster diagram  
□ Lead lab coat  
□ Time card  
□ (2) Sticker sets for how to present graph (changing ball and ramp)  
□ (8) Partial graph pieces  
□ (2) Pencils  
□ (5) Paperclips  
□ (2) Wet erase markers  
□ (2) Highlighters  
□ Scissors  
□ (2) Glues  
□ Scotch tape  
□ (1 each color) Poster part pack
**Preparation:**

**SciTrek Lead:**
1. Make sure volunteers are setting out notebooks.
2. Ask the classroom teacher for a place to leave the student posters in the classroom.

**SciTrek Volunteers:**
1. Set out notebooks/nametags.

**Note:** If students are not in the classroom before SciTrek starts, notebooks should be set out where students should sit when they come into the classroom. If students are in the classroom before SciTrek starts, notebooks should be set out where students should sit during the module; they will move to these spots after the introduction.

**Introduction:**
*(2 minutes – Full Class – SciTrek Lead)*

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.

Ask the class, “What is the class question that we have been investigating?” Students should reply, “What variables affect ball motion?” Tell students that today they are going to analyze the results from their experiments, which will allow them to start answering the class question. Then they will put together a
poster to show their findings to the class. Tell students they should write as neatly as possible on the poster parts so that the other class members can read their poster.

**Graph:**

*(10 minutes – Groups – SciTrek Volunteers)*

Ask your group, “What did we do last time in SciTrek?” Have them explain their experiment to you without looking at their notebooks.

Pass out one partial graph piece to each student and have them fill out the piece for the trial they oversaw. There is an extra partial graph piece in the group box that you should use as an example. On the bottom line, have students write the value of their changing variable (Ex: 150 g), not the trial letter or the changing variable (Ex: A or ball mass). This way when the pieces are rearranged, they will be able to see the values for each of the trials to help them identify any patterns. The graph will have a scale provided. Each large line represents 1 second, each smaller line represents \( \frac{1}{10} \) of a second. Have students draw a line across the column showing the median time for their trial as well as write in the numerical value of the time on top of the line and then quickly shade below the line. Once each student has completed their graph piece, have students help you arrange the partial graph pieces so that they are in increasing order as done in the example below. In the example experiment discussed, the trials were graphed in the following order: B, A, C, D. Tape the partial graphs to the group notepad so that they look like a complete graph (see example group notepad below). When taping the graph pieces to the group notepad, make sure that each graph piece overlaps with the one next to it so that you only see the y-axis for the first graph piece.

![Graph Example](image1.png)

After the pieces of the graph are taped into the group notepad, ask students, “What is our changing variable?” Record this answer for the x-axis title and have students copy this into their notebooks.
Results Summary:
(10 minutes – Groups – SciTrek Volunteers)

Have students use their graph to look for a pattern in their data. Challenge students to think about how their changing variable did or did not affect ball motion.

When writing their results summary (page 9, student notebook), make sure students start the statement with a claim (a statement that can be tested) about the trend or pattern in their data. If the values of their changing variable have an order (Ex: 13 cm → 15 cm → 25 cm), then that variable affected ball motion. If, on the other hand, there was no order for their changing variable values (Ex: 150 g → 250 g → 50 g) and the difference between the times is small, then that variable did not affect ball motion. If possible, try to have students generate a claim that allows them to make a prediction about something that they have not tested. An appropriate claim could be: ball mass does not affect the time the ball travels. This is an appropriate claim because it allows the students to make a prediction about what would happen if new values of their changing variable were introduced.

After generating a claim about their experiment, write the word “because” and follow it with supporting data. Their supporting data should include at least two pieces of data, typically the minimum and maximum times. Make sure students are using their changing variable values (not trial letters) and specific measurements to support their claim. The supporting data for the previously mentioned claim would be: because the 165 g ball took $1\frac{6}{10}$ s and the 360 g ball also took $1\frac{6}{10}$ s to hit the board.

Results summaries are still valid, and important, if they show that the changing variable tested did not affect ball motion. Even if their results summary is contrary to what you think, have students make a claim based solely on their data. Help students copy this statement into their notebooks.

Before starting their poster, have students fill in the sentence frame (page 10, student notebook): “I acted like a scientist when.” Each student’s response should be unique and specific. They should NOT write, “when I did an experiment,” because this is general and applies to all of the students in the class. If students are having trouble with this sentence frame, ask them what they did during each SciTrek session.

Poster Making:
(33 minutes – Groups – SciTrek Volunteers)

Pass out the writing portions (general poster parts and “I acted like a scientist when”) and have students write their names on them and complete them. In addition, have each student write their name on the scientists’ names poster part. Use the following guidelines when assigning poster parts:
<table>
<thead>
<tr>
<th>Number of Students in Group</th>
<th>Poster Division</th>
<th>Each student gets an “I acted like a scientist when” and picture space.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1. Question and Experimental Set-Up</td>
<td>Student that finishes 1st completes the results table (not presented)</td>
</tr>
<tr>
<td></td>
<td>2. Procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Results Graph*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Results Summary</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1. Question</td>
<td>Student that finishes 1st completes the results table (not presented)</td>
</tr>
<tr>
<td></td>
<td>2. Experimental Set-Up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Results Graph*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Results Summary</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1. Question</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Experimental Set-Up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Procedure (Presents 1st half of procedure)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Results Table (Presents 2nd half of procedure)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Results Graph*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Results Summary</td>
<td></td>
</tr>
</tbody>
</table>

*Give the results graph to the student that is most confident in presenting.

Once students have finished the writing section(s), have them draw a picture of their experiment or how they acted like a scientist.

In the students’ notebooks, **highlight and number the section(s) that they will present**. The parts should be numbered as follows: 1) scientists’ names, 2) question, 3) experimental set-up, 4) procedure, 5) results graph, and 6) results summary (see example below). Students will NOT present the results table or “I acted like a scientist when” parts from their poster. If a student is presenting multiple sections, use the paperclips in your group box to clip together the sections that they are reading so that when presenting, it will be easy to flip back and forth between pages.

Example Highlighted Notebook Pages
Place one of the following sentence frame stickers on the notebook page of the student that is presenting the results graph (page 9, student notebook).

**Changing Ball Circumference/Mass:**

| The ball with a [ ] of [ ] hit the board in [ ] seconds. |
|---|---|---|
| circumference or mass | changing variable value | measurement |

**Changing Ramp Length/Height and Run Length:**

| The ball on the [ ] ramp hit the board in [ ] seconds. |
|---|---|---|
| changing variable value | tall or long | measurement |

Then practice reading the four sentences with that student. For the graph above, the first sentence would be: The ball with **mass** of **165 g** hit the board in **1 \( \frac{6}{10} \)** seconds. Make sure you fill in the first blank in the first sentence frame (Ex: mass) for the student but leave the “changing variable value” and “measurement” blanks empty. An example of a sentence for a group that changed ramp height would be: The ball on the 30 cm **tall** ramp hit the board in **1 \( \frac{2}{10} \)** seconds. Make sure you fill in the second blank in the second sentence frame (Ex: tall) for the student but leave the “changing variable value” and “measurement” blanks empty. If your group’s changing variable was run length, use the second sentence frame, but cross out the word “ramp” and change it to the word “run”. An example of a sentence for a group that changed run length would be: The ball on the **100 cm long** ramp **run** hit the board in **1 \( \frac{6}{10} \)** seconds.

As soon as students have completed some of their pieces, start gluing them onto the large poster paper, in landscape orientation, exactly as they are arranged in the example below. Do not allow students to glue the poster parts on the poster. Do not wait until students have completed all the pieces to start gluing them onto the poster.

Once the poster is complete, have students start practicing for the presentation. Make sure that students read from their notebooks instead of off the poster.
Ask your group a few questions about their poster. Have them use their findings to predict what would happen to ball motion for other changing variable values that they did not perform but are related to their experiment. For instance, if the group’s results summary was, “My experiment shows that ball mass does not affect the time the ball takes to hit the board because the 165 g ball took $1 \frac{6}{10}$ s and the 360 g ball took $1 \frac{6}{10}$ s to hit the board as well,” ask the group, “If you tested a 500 g ball, how much time would it take to hit the board?” They should be able to predict that it would be $1 \frac{6}{10}$ s.

If there is additional time, tell students that the other students will ask them questions during their poster presentations. Tell them that they should think about what questions they will be asked and then think of the answers to those questions so that they will be prepared during their presentation.

**Wrap-Up:**

*(5 minutes – Full Class – SciTrek Lead)*

Ask students the following questions:

How did you act like a scientist during this project?

What did you do that scientists do?

After having a discussion about how they acted like scientists and talking about how everyone does things that scientists do in their everyday lives, tell students that they will present their findings during the next session and that you are looking forward to hearing about all of their experiments.
Clean-Up:

1. Collect notebooks with attached nametags.
2. Leave posters in the classroom.
3. Place all other materials in your group box and bring materials back to UCSB.

Day 5: Poster Presentations

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Practice Posters (SciTrek Volunteers) – 15 minutes
- Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 41 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(4) Volunteer Boxes:

- □ Student nametags
- □ Student notebooks
- □ Volunteer instructions
- □ Volunteer lab coat
- □ (2) Pencils
- □ (2) Paperclips
- □ Highlighter

Lead Box:

- □ (3) Extra student notebooks
- □ Lead instructions
- □ Motion picture packet
- □ Lead lab coat
- □ Time card
- □ (2) Sticker sets for how to present graph (changing ball and ramp)
- □ (2) Pencils
- □ (2) Wet erase markers
- □ (4) Paperclips
- □ (2) Highlighters
- □ Scotch tape

*Student posters should already be in the classroom.
**Preparation:**

**SciTrek Lead:**
1. Assign volunteers a new group to work with. This will allow students to explain what they found and practice their poster with a new person.
2. Make sure volunteers are setting out notebooks.
3. If the classroom has a document camera, ask the teacher to use it for the Notes on Presentations (page 2, picture packet). If the classroom does not have a document camera, then write the class question on the board, “What variables affect ball motion?” Leave enough room to record student findings under the question.
4. Organize posters so experiments featuring the same changing variable are presented back to back and posters are presented from easiest to understand to hardest to understand (suggested order: run length, ramp height, ramp length, ball circumference, ball mass).

**SciTrek Volunteers:**
1. Today you will initially work with a new group of students. When your original group presents their poster, go up with them.
2. Set out notebooks/nametags.

**Note:** If students are not in the classroom before SciTrek starts, notebooks should be set out where students should sit when they come into the classroom. If students are in the classroom before SciTrek starts, notebooks should be set out where students should sit during the module; they will move to these spots after the introduction.
**Introduction:**
(2 minutes – Full Class – SciTrek Lead)

Tell students that today they will present their posters to the class. Inform students that this is a common practice in science. Scientists go to conferences where they present posters about the experiments they conducted. At these presentations, other scientists give them feedback on their experiments, which allows them to return to the lab with new ideas for future experiments.

Tell students that today they will work with a new volunteer. They will have 15 minutes to discuss their experiment/results and practice presenting their poster with their group. While discussing their experiment/results, students should not look at their notebooks or poster. Remind students to read from their notebooks when presenting. Tell students that after practicing, they will return to their normal classroom seats.

**Practice Posters:**
(15 minutes – Groups – SciTrek Volunteers)

Have volunteers rotate groups.

If the posters are not already in order, the lead should organize posters so experiments featuring the same changing variable are presented back to back and that posters are presented from easiest to understand to hardest to understand (suggested order: run length, ramp height, ramp length, ball circumference, ball mass).

Have students explain what they did and what they learned from their experiment, without looking at their notebooks, if possible. Ask students questions to make sure that they understand what they did during their experiment. Make sure that you also have them use their results to predict what would happen for other systems that they did not test. Remind them to think about patterns or trends that they saw for their own results and apply these trends to make predictions about ball motion. For instance, if the group’s changing variable was ball mass, ask them, “How much time do you think it would take for a ball of mass 125 g (this would be a mass that they did not test) to hit the board?” Possible answer: the same time it took for the other trials because changing ball mass did not change the time it took for the ball to hit the board. Try to make sure that each student in your group answers one question.

Once the group has an understanding of their experiment, have them practice their poster presentation, making sure they are reading the poster parts in the correct order (scientists’ names, question, experimental set-up, procedure, results graph, and results summary). Make sure each student’s part is highlighted in their notebook. If students are reading from multiple pages, use a paperclip to clip these pages together to make it easier for them to flip back and forth. Remind students to read from their notebook rather than from their poster.

If there is additional time, tell the group that the other students will ask them questions during their poster presentations. Tell them that they should think about what questions they will be asked and then think of the answers to those questions so that they will be prepared during their presentation.

Do not let poster practice go over 15 minutes.

**Poster Presentations:**
(41 minutes – Full Class – SciTrek Volunteers/SciTrek Lead)

Have students return to their original class seats. Ask the class, “What is the question we have been working on solving?” Students should reply, “What variables affect ball motion?” Ask the class, “Why are...
we interested in answering this question?” Possible student response: if we can determine the variables that affect ball motion then we will be able to predict other types of motion. Tell students that during the presentations you are going to take notes. Turn to page 2 in the picture packet. Tell them that they need to tell you each group’s changing variable after the group says their question so that you can record it. In addition, you will record the values of the changing variable and the measurements when the group presents their graph.

After each presentation, students will be given the opportunity to ask scientific questions to the presenting group to help them determine if/how the variable investigated affected ball motion. Tell them these questions are important because they will have to summarize for you what they learned from the group so you can record it on the group notes. Therefore, their questions should focus on helping them be able to summarize the group’s findings.

Volunteers should make sure that students are quiet and respectful when other groups are presenting. When your group is presenting, go to the front of the room with them; prompt students if they do not know who talks next and remind them to read from their notebooks.

During the student question time, the lead and/or volunteers should ask at least one question. Examples of possible questions are: “How do you know...?” or “Can you predict what the time would be if you use (untested changing variable value)?” Each group should answer approximately five questions (one question per student).

When students are done asking questions, have them summarize what the group found. This is challenging for 3rd graders, therefore, you need to break it down into the following four question 1) What was the group’s changing variable? 2) (point to the notes where you recorded the values of the changing variable) What pattern do you see in the (insert changing variable)? 3) (point to the notes where you recorded the time) What pattern do you see in the time? 4) Who can put this all into a sentence? If they are still having trouble give them the sentence frame “As the (insert changing variable) (insert pattern) the time for the ball to hit the board (insert what happens)” Ex: As the run length get longer the time for the ball to hit the board gets longer. Once they have generated a summary, record this on the notes page.

An example filled out Notes on Presentations is shown below.
After all poster presentations have been given, ask the class, “What did we learn about ball motion?” Have them summarize the class findings. The highlights from many experiments are shown below. Do not expect students to know highlights from experiments that were not run.

- The longer the run length the more time it takes for the ball to hit the board.
- As the ramp height gets taller (up to about 45°), the less time it takes for the ball to hit the board. **Note:** if the ramp is above a 45° angle, then energy is lost when the ball hits the ground after coming off the ramp and the ball takes longer to hit the board.
- Ramp length does not affect the time it takes for the ball to hit the board.
- Ball circumference does not affect the time it takes for the ball to hit the board. **Note:** The balls do have slightly different moments of inertia which would affect their speeds, however over the distance that the students are looking at usually this is not seen.
- Ball mass does not affect the time it takes for the ball to hit the board.

When summarizing experiments, use student collected data and not what they should have found from the list above. Ask students, “What values of variables would you need to get a ball to hit the board at 200 cm in as little time as possible?”

- Run Material: Smooth material
- Ramp Length: Any length
- Ramp Height: 35 cm (for a ramp length of 50 cm this will give a 45° angle)
- Ball circumference: Any circumference
- Mass: Any mass

If no one in the class did experiments on one of the variables above, then they will not know how that variable affects ball motion and do not expect them to tell you which value to use. Tell students they have taught you a lot about ball motion.
Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell the students that the volunteers that have been working with them are undergraduate and graduate students that volunteer their time so that they can do experiments. Have the students say thank you to the volunteers. This is the last day with their volunteers, therefore, they should say goodbye to them. Tell students that you will be back one more time.

Tell students to remove the paper part of their nametag from the plastic holder and that they can keep the paper nametag, but they need to give the plastic holder back to their volunteer.

Clean-Up:

1. Collect plastic nametag holders and allow students to keep the paper part of the nametag.
2. Collect notebooks.
3. Leave poster in the classroom.
4. Place all other materials into your group box and bring materials back to UCSB.
5. If you will not be attending the Tie to Standards day, remove all materials from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Day 6: Question Assessment/Draw a Scientist/Tie to Standards/Content Assessment

Schedule:

- Question Assessment (SciTrek Lead) – 10 minutes
- Draw a Scientist (SciTrek Lead) – 5 minutes
- Tie to Standards (SciTrek Lead) – 35 minutes
- Content Assessment (SciTrek Lead) – 10 minutes

Materials:

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Student notebooks
- ☐ Lead instructions
- ☐ Motion picture packet
- ☐ Lead lab coat
- ☐ (25) Question Assessments
- ☐ (25) Draw a Scientist
- ☐ (25) Content Assessments
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Wet erase markers
- ☐ Teacher final survey QR code
- ☐ (2) Light blue balls (27 cm circ., ~265 g)
- ☐ Purple ball (27 cm circ., ~360 g)

Other Supplies:
- ☐ 5 ft x 2 ft outdoor carpet with measurement mark
- ☐ 125 cm x 30 cm of Astroturf
- ☐ (2) Boards (50 cm x 30 cm) with outdoor carpet
- ☐ Board (50 cm x 30 cm) with Astroturf
- ☐ Board (100 cm x 30 cm) with marks on back side
- ☐ Ball stop board (65 cm x 30 cm)
- ☐ (2) Wood ramp holders (13 cm tall)
- ☐ Wood ramp holder (22 cm tall)
I acted like a scientist when I measured how long it took the ball to hit the board.

TIE TO STANDARDS

1. What two measurements do you need to get the speed of an object? 
   \[ \text{time} \quad \text{and} \quad \text{distance} \]

2. If all distances are equal, the ball that hits the board first has a faster speed.

Ramp Height

3. Fill out the following chart. Predict which set-up will cause the ball to hit the board first and circle your answer in the prediction column. For each of the trials write the set-up that hit the board first, or \('\text{Tie}'\) if the two balls tied.

<table>
<thead>
<tr>
<th>Set-Up 1</th>
<th>Set-Up 2</th>
<th>Prediction</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Height: 15 cm</td>
<td>Ramp Height: 25 cm</td>
<td>(2\text{ cm} )</td>
<td>Tie</td>
</tr>
</tbody>
</table>

4. Does the ramp height affect the speed of the ball? \(\text{Tie} \quad \text{NO}\)

5. Explain how ramp height affects the speed of the ball.
   \[ \text{The taller the ramp the faster the ball hits the board.} \]

Ball Mass

6. Fill out the following table with the same directions as question 3.

<table>
<thead>
<tr>
<th>Set-Up 3</th>
<th>Set-Up 4</th>
<th>Prediction</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball Mass: (155 \text{ g})</td>
<td>Ball Mass: (160 \text{ g})</td>
<td>(5)</td>
<td>Tie</td>
</tr>
</tbody>
</table>

7. Does the ball mass affect the speed of the ball? \(\text{YES} \quad \text{NO}\)

8. Explain how the ball mass affects the speed of the ball.
   \[ \text{Ball mass does not affect the speed of the ball.} \]

Run Material

9. Which ball do you think will hit the wooden run first when dropped from the same height?
   \[ \text{Blue Ball} (-165 \text{ g}) \quad \text{Purple Ball} (-160 \text{ g}) \]

10. Which ball hit the ground first? \(\text{Tie} \quad \text{Tied}\)

Is motion predictable?

11. Circle the values below that would cause a ball to travel at the fastest speed. If the variable does not affect the speed of the ball, then circle either. Assume a ramp length of \(50 \text{ cm}\) and a run length of \(150 \text{ cm}\).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Height:</td>
<td>(10 \text{ cm})</td>
<td>(20 \text{ cm})</td>
<td>(30 \text{ cm})</td>
</tr>
<tr>
<td>Ball Mass:</td>
<td>(100 \text{ g})</td>
<td>(1000 \text{ g})</td>
<td>(10 \text{ g})</td>
</tr>
<tr>
<td>Run Material:</td>
<td>Sand Paper</td>
<td>Flash Paper</td>
<td>Cardboard</td>
</tr>
</tbody>
</table>

12. Does the run material affect the speed of the ball? \(\text{YES} \quad \text{NO}\)

13. Explain how run material affects the speed of the ball.
   \[ \text{The smoother the run material the faster the ball.} \]

14. Circle the values below that would cause a ball to travel at the slowest speed. If the variable does not affect the speed of the ball, then circle either. Assume a ramp length of \(50 \text{ cm}\) and a run length of \(150 \text{ cm}\).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Height:</td>
<td>(10 \text{ cm})</td>
<td>(20 \text{ cm})</td>
<td>(30 \text{ cm})</td>
</tr>
<tr>
<td>Ball Mass:</td>
<td>(1 \text{ g})</td>
<td>(10 \text{ g})</td>
<td>(100 \text{ g})</td>
</tr>
<tr>
<td>Run Material:</td>
<td>(\text{Tie})</td>
<td>Cardboard</td>
<td>Either</td>
</tr>
</tbody>
</table>

15. Circle the values below that would cause a ball to travel at the slowest speed. If the variable does not affect the speed of the ball, then circle either. Assume a ramp length of \(50 \text{ cm}\) and a run length of \(150 \text{ cm}\).
Preparation:

SciTrek Lead:
1. If the teacher is not leading the Tie to Standards Activity, do the following:
   a. Ask the teacher if they completed the SciTrek final survey. If not, give them the QR code and ask them to go to the website (at a later time) and fill out the evaluation of the program.
   b. Give the teacher an extra student notebook and have them fill it out with their students to follow along.
   c. Collect the teacher’s lab coat and put it in the lead box.
2. If you are a teacher and did not complete the SciTrek final survey, take the QR code from the lead box and use it to fill out the evaluation of the program at a later time.
3. Pass out Question Assessment and notebooks to students or get the classroom teacher to pass them out.
4. If the classroom has a document camera, ask the teacher to use it for the Tie to Standards Activity (pages 10-12, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
5. Assemble the Tie to Standards set up (seen in picture below as well as on page 3 of the picture packet).
   a. Roll out the 5 ft × 2 ft carpet onto a table in the front of the class (if it is not possible to do this on a table then it can be done on the floor, see floor set-up note below).
   b. Set up two 50 cm × 30 cm outdoor carpet covered ramps on the two different wood ramp holders (heights 13 cm tall and 22 cm tall).
   c. Align the ramps so the bottom of the ramps are sitting on the 50 cm mark on the carpet.
   d. Set the ball stop board at the 150 cm mark (Set-Up 1).
   e. Have the rest of the Tie to Standards materials close (purple ball, 2 light blue balls, additional 13 cm tall wood ramp holder, board with Astroturf, wood board 100 cm, and Astroturf).
6. Put your lab coat in the lead box at the end of the day.

Floor Set-Up Note:
If you must set up on the floor, after you have the students make their first prediction (testing the ramp height) you need to warn the students about all the moving that will take place during today’s session. Give the students the following instructions: “On the count of three, I want everyone to stand up and move around the carpet set-up so that you are able to see our
The people in the front must sit so that those behind them can see. I will make sure that everyone is able to see before I start the trials, but remember that the quicker and quieter you all get set, the sooner we will be able to see each experiment. In addition, when you get to the carpet set-up make sure not to touch it. Let’s see how we do. One... two... three.” The first time, you may need to direct students whether they need to sit, kneel or stand. After each experiment have students return to their seats. Tell students that we will repeat this process two more times during the session.

SciTrek Volunteers:
Help the lead change out the ramps during the activity. Once the lead is done testing ramp height with the class remove one of the 50 cm ramps and the 22 cm ramp holder. Place a second 13 cm ramp holder under the 50 cm ramp that is left. This will be used for testing ball mass (Set-Up 2). Once the lead is done testing ball mass, place the Astroturf over the outdoor carpet on half of the set-up and place the 100 cm ramp wood side up on the other half of the set up. Then replace one of the ramps with an Astroturf ramp. The wooden ramp is the outdoor carpet ramp turned over (Set-Up 3).

**Question Assessment:**
*(10 minutes – Full Class – SciTrek Lead)*

“Before we start our activity today, we will determine how your ideas on testable questions are developing. One of the ways that we get program funding is by demonstrating program effectiveness. Therefore, we need you to do your best on the assessment.” Pass out the Question Assessment and tell students to fill out their name, teacher’s name, and date on the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

Read the instructions to the students. Then read each of the questions and tell the students to circle “testable” for questions that science can answer or “not testable” for questions that science cannot answer.

When students are finished, have them turn over their paper. Read the three Attitudes Towards Science questions to students and have them answer them. When they are finished, collect the assessments and verify that the students’ names are on the top of the papers.

**Draw a Scientist:**
*(5 minutes – Full Class – SciTrek Lead)*

Pass out the draw a scientist paper. Tell students to fill out their name, teacher’s name, and date on the top of the assessment. Give students exactly 4 minutes to draw a picture of a scientist. Once they are done, ask them to write on the bottom line who they drew a picture of. If it was no one specific, they can leave the line blank. Then collect the papers from students, verifying that their names are on the top of the papers.

**Tie to Standards:**
*(35 minutes – Full Class – SciTrek Lead)*

Tell the class that you enjoyed their poster presentations the last time you were there and today they are going to revisit some of the variables that affected ball motion. Have students turn to page 10 of their notebooks. Place the class notebook under the document camera and turn to page 10.
Ask students, “What did you measure during your experiments?” Possible student response: we were measuring the time it took for the ball to hit the ball stop board, which was a set distance from the top of the ramp. Tell students, “I heard some of you talking about ball speeds during the module and I was wondering what you meant by this because it seems like you only measured the time. Therefore, how would you be able to tell anything about speed?” By the end of the conversation, make sure that students understand that to get a speed they need to measure time and distance. If students have trouble generating time and distance ask them, “Would it be fair to have two students race, one running one lap around the school and the other running ten laps around the school? Which of these students would finish the race first and why?” Students should be able to determine that the student running one lap will finish in a shorter time than the student running ten laps but that this does not mean than the student running one lap ran faster. Therefore, in order to accurately determine speed, they need both time and distance. Since both time and distance were measured during their experiments they can talk about the speeds of the balls. Have students fill in questions 1 and 2 on page 10. See example below.

**TIE TO STANDARDS**

1. What two measurements do you need to get the speed of an object?  
   time and distance

2. If all distances are equal, the ball that hits the board first has a (faster/slower) speed.

**Effects of Ramp Height (8 minutes)**

Show students the set-up on the table. Tell students, “I am going to roll two balls that have the same circumference (27 cm) and mass (~265 g) down the two ramps which are 13 cm tall and 22 cm tall. I will then allow the balls to roll for 150 cm before the balls will hit the ball stop board. Before I do this experiment, I want you to predict what you think will happen and record this prediction in your notebook for question 3.” Allow students time to make their predictions and then have one student share what they think and why. After, have the rest of the class vote if they agree/disagree with the student’s prediction using thumbs up/thumbs down.

Set the two light blue balls at the top of the ramps and release the balls at the same time. In the “trials” column of question 3 record which set-up made the ball hit the board first. Fill in the result of trial 1 on the class notebook under the document camera. Repeat the process two more times for trials 2 and 3.

Ask students, “Did the ramp height affect the time it took the ball to hit the board?” Students should reply, “Yes.” Have the students circle “yes” for question 4. Have a few students summarize the relationship between ramp height and the time it takes for a ball to hit the board. Write one of these sentences in the class notebook and have students copy it into their notebook. See example student work below.

**IMPORTANT:** If there is no SciTrek volunteer in the room, as students are writing about how ramp height affects the speed, remove the 22 cm ramp holder and one of the 50 cm ramps. Place a second 13 cm ramp holder under the 50 cm ramp that is left (Set-Up 2).
Ask students, “Do you think that the taller ramp will always result in the ball hitting the board faster?” If a group explored ramp height as a changing variable they might have found that increasing the ramp height decreases the time it takes for the ball to hit the ball stop board, until the ramp has an angle of ~45° (for the 50 cm ramp length, 45° occurs when the ramp height is 35 cm). Anything greater than this angle increases the time it takes for the ball to hit the ball stop board. (If this variable was not investigated by a group take one of the ramps and increase the ramp height until the ramp is at a 90° from the run. Ask students, “Will the ball reach the ball stop board slower or faster than the other ramp that is set-up?” Students should predict that when the ramp is at 90°, the ball will never reach the ball stop board. Therefore, if the ramp gets too steep the time it takes to reach the ball stop board increases.) Ask the class, “Why does it take more time for the ball to hit the ball stop board when the board is vertical or almost vertical?” By the end of the conversation make sure that students understand that the taller the ramp, the more energy the ball has. However, more of the ball’s energy is directed in the downward direction (z direction), therefore, less of the energy is directed along the ramp (x direction). (In other words, the fall causes the ball to transfer a significant amount of energy into the table; therefore, the ball does not travel as far. The extreme of this is shown when the ramp is at 90° and the ball does not travel in the x direction.)

Effects of Ball Mass (10 minutes)

Tell students, “I am going to roll two different balls down a ramp that is 13 cm off the ground. One of the balls has a mass of ~265 g (light blue ball) and the other ball has a mass of ~360 g (purple ball) and both balls have the same circumference (27 cm). The balls will roll for 150 cm before the balls will hit the ball stop board. Before I do this experiment, I want you to predict what you think will happen and record this prediction in your notebook for question 6.” Allow students time to make their predictions and then have one student share what they think and why. After, have the rest of the class vote if they agree/disagree with the student’s prediction using thumbs up/thumbs down.

Set the two balls at the top of the same 13 cm outdoor carpeted ramp, each against their own ramp holder, and release the balls at the same time. In the “trials” column of question 6 record which set-up made the ball hit the ball stop board first. Fill in the result of trial 1 on the class notebook under the document camera. Repeat the process two more times for trials 2 and 3. If students are having a hard time agreeing that the balls have tied, ask them, “If the balls tie, should you hear one hit or two hits when the balls hit the board?” Students should reply, “one hit.” Tell students that if the balls do not tie then they will hear two hits. Have the students close their eyes and listen to what happens.
Ask students, “Does ball mass affect the time the ball takes to hit the board?” Students should reply, “No.” Have students circle “no” for question 7. Have a few students summarize the relationship between ball mass and the time it takes for a ball to hit the board. Write one of these sentences in the class notebook and have students copy it into their notebook. See example student work above.

**IMPORTANT:** If there is no SciTrek volunteer in the room, as students are writing about how ball mass affects the speed, place the Astroturf over the outdoor carpet on half of the set-up and place the 100 cm ramp, wood side up, on the other half of the set up. Then replace one of the ramps with an Astroturf ramp. For the wooden ramp, turn the outdoor carpet ramp over (Set-Up 3).

Tell students that you will now drop the light blue and purple balls onto the wooden run. Have students predict which ball will hit the wooden run first and circle their prediction for question 9. Have one student share what they think and why. Then have the rest of the class vote if they agree/disagree with the student’s prediction using thumbs up/thumbs down. Hold one ball in each hand, and make sure that the balls are at approximately the same height. Drop the balls at the same time onto the wooden run so students can hear the balls hit. Students will observe that the balls will hit the run at the same time. Have them record this for question 10. Ask students, “How does ball mass affect both rolling balls down a ramp and dropping balls?” Students should realize the mass does not affect the speed the ball travels in either of the two cases.

**Note:** If a feather and a BB (ammo pellet) were dropped at the same time from the same height the BB would hit the ground first. This is not because the BB is heavier than the feather. This is because the feather is larger and encounters more air resistance. If the feather and the BB were dropped at the same time from the same height in a vacuum (where there is no air, and no air resistance) both would hit the ground at the same time.

**Effect of Run Material (8 minutes)**

Tell students, “I am going to roll two balls that have the same circumference (27 cm) and mass (250 g) down the ramps/runs that are made of different materials. One run will be made out of wood and the other run will be made out of Astroturf. Both ramps will have a height of 13 cm. I will then allow the balls to roll for 150 cm before the ball will hit the ball stop board. But before I do this experiment, I want you to predict what you think will happen and record this prediction in your notebook for question 11.” Allow students time to make their predictions and then have one student share what they think and why. After, have the rest of the class vote if they agree/disagree with the student’s prediction using thumbs up/thumbs down.
Set the two balls at the top of the ramps and release the balls at the same time. In the “trials” column of question 11, record which set-up made the ball hit the ball stop board first. Fill in the result of trial 1 on the class notebook under the document camera. Repeat the process two more times for trials 2 and 3.

Ask students, “Does run material affects the time the ball takes to hit the board?” Students should reply, “Yes.” Have the students circle “yes” for question 12. Have a few students summarize the relationship between run material and the time it takes for a ball to hit the board. Write one of these sentences in the class notebook and have students copy it into their notebook. See example student work below.

**Run Material**

11. Fill out the following table with the same directions as question 5.

<table>
<thead>
<tr>
<th>Set Up 1</th>
<th>Set Up 6</th>
<th>Prediction</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Material: Turf</td>
<td>Run Material: Wood</td>
<td>Which set-up will cause the ball to hit the board first? (directed)</td>
<td>YES</td>
</tr>
<tr>
<td>Turf</td>
<td>Wood</td>
<td>YES</td>
<td>Turf</td>
</tr>
</tbody>
</table>

12. Does the run material affect the speed of the ball? _YES_ _NO_

13. Explain how run material affects the speed of the ball.

The smoother the run material, the faster the ball.

Explain to the students that the material objects travel over has a large effect on the motion of the object. The smoother the run material, the faster an object will move. The resistance the object encounters when moving is called friction. Have the students rub their hands together and ask them, “What do you feel?” Students should reply, “Heat.” This feeling is also because of friction. Tell the students that even when a ball is thrown through the air it encounters friction from the particles like nitrogen in the air (air resistance). This is why eventually a thrown object will fall to the ground. _Note:_ Gravity also plays a role, but the ball would travel much farther if there was no air resistance/friction. Ask students, “Would there be friction if a ball was thrown in outer space?” Possible student response: there is no air in outer space so there would not be friction (no air resistance). Ask students, “What would happen if a ball was thrown in outer space?” Allow students to share their thoughts and by the end of the conversation make sure students understand that if a ball was through in outer space the ball would just keep going in the direction that you throw it forever because there would be nothing to slow it down.

**Teacher/Lead Note: Effect of Ramp Length**

Only address ramp length if a student asks a question about the effects of ramp length. This variable is the hardest for students to understand and is contrary to what simple Newtonian physics predicts.

In theory, ramp length should not affect the time it takes for the ball to hit the ball stop board or the speed of the ball. The stored energy of the ball only depends on the original height and mass of the ball. Since the same ball was used for all the trials (therefore the mass of the ball is the same) and the ball started at the same height, all trials should have the same amount of stored energy. Since they all have the same amount of stored energy, the ball should have the same final speed for all trials. However, experimentally students will see that the ball hit the stop board in slightly different amounts of time. They will find that the smaller the angle between the tabletop and the ramp, (resulting in a less steep slope) the faster the ball will travel (the sooner it will hit the ball stop board). When a ball is released from the top of the ramp the ball has velocity in the z (downward) and x (direction towards the run) directions. The steeper the ramp, the larger the z component of the velocity and the smaller the x component of the velocity. As the ball comes off the ramp and hits the run, if the z component of the velocity is large, the ball hits the run more forcefully and transfers a large percentage of its energy into the run. This energy is
no longer available to propel the ball down the run. The extreme of this phenomena can be easily observed if the ramp is at a 90˚ angle. When the ball is released the ball falls and hits the run and essentially does not roll down the run.

**Motion Predictability (5 minutes)**

Ask students, “Do you think that ball motion is predictable and why?” Have a few students share their answers with the class. Tell the students that you want to design a set-up in which the ball travels as fast as possible. Ask students, “Does this mean that the ball would hit the ball stop board in more or less time?” Students should reply, “Less.” Tell students, “When designing this set-up there are only a few variables that we can choose from and I need your help to identify the variables that we should use.” Have students individually go through the variables in question 14(a) and circle each value that they think would allow the ball to travel the fastest. After they have filled out the question, have one student share each variable that they chose and ask the class if they agree/disagree with thumbs up/thumbs down. An example of student work can be seen below.

Repeat the above procedure for question 14(b), however this time, students need to determine the variable that would allow the ball to travel the slowest. An example of student work can be seen below.

Tell the students that you have enjoyed working with them and you have learned a lot about ball motion from them. You now know that motion is predictable, and the ball mass does not affect the speed of the ball but that ramp height, ball circumference, and run material will affect the speed. Tell students that before you leave, you would like to see how their science content knowledge has changed.
**Content Assessment:**
(10 minutes – Full Class – SciTrek Lead)

Tell students to close their notebooks and to place them in the corner of their desk. Pass out the Content Assessment to the students. Tell students to write their name, teacher’s name, and date on the top of their paper. During the assessment, remind students to work by themselves. Read each of the content questions to the students and have them select/fill out the correct answer. When students are finished, collect the assessments and verify that they have written their name on the assessment.

Tell students that they can keep their notebooks and that you have enjoyed working and learning with them, and you hope they continue to see themselves as scientists and explore the world around them.

**Clean-Up:**

1. Leave notebooks with students.
2. Place materials in your group box and bring materials back to UCSB
3. Remove all materials from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

**Extra Practice Solutions:**

<table>
<thead>
<tr>
<th>EXTRA PRACTICE</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Circle</strong> <strong>TESTABLE</strong> if the question can be tested by science. Circle <strong>NOT TESTABLE</strong> if the question cannot be tested by science. If the question is <strong>NOT TESTABLE</strong> change (revise) the question to something that is testable.</td>
<td></td>
</tr>
<tr>
<td>1. How much time does it take to walk three miles?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision:</td>
<td></td>
</tr>
<tr>
<td>2. Is a bird loud?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision: What species of bird chirps the loudest?</td>
<td></td>
</tr>
<tr>
<td>3. Is drinking eight glasses of water a day a good idea?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision: How many glasses of water does a doctor recommend drinking in a day?</td>
<td></td>
</tr>
<tr>
<td>4. How many songs does the radio station play in one hour?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision:</td>
<td></td>
</tr>
<tr>
<td>5. Which type of juice is the most refreshing?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision: How many apples are used to make a cup of apple juice?</td>
<td></td>
</tr>
<tr>
<td>6. Do bees land on bright colored flowers?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision:</td>
<td></td>
</tr>
<tr>
<td>7. Is ice cream more delicious than cookies?</td>
<td>Testable</td>
</tr>
<tr>
<td>Revision: Which has more sugar: ice cream or a cookie?</td>
<td></td>
</tr>
</tbody>
</table>