This document is not intended to give you all of the information you need to lead the module. You can find the complete instructions at http://www.chem.ucsb.edu/scitrek/module. This document is intended to be used as a reference during the module.

**Important Things to Remember During the Module**

1. You are responsible for keeping track of time in the classroom and making sure that ALL activities run smoothly. There will be a time card in the lead box with suggested times to start/stop each activity.
2. You are responsible for keeping volunteers and students on track.
3. Walk around during times volunteers are working with students and help struggling groups.

**Day 1: Question Assessment/Technique/Observations/Reproducibility Discussion/Variables**

*Schedule: You are responsible for **BOLD** sections*

- 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 Volunteer) – 13 minutes
- Wrap-Up (SciTrek Lead) – 3 minutes

*Preparation:*

1. If the classroom has a document camera, ask the teacher to use it for the technique (page 2, student notebook) and class data (page 1, picture pack).
2. Write the four group colors on the board (purple, orange, blue, and green) and the volunteer’s name that will be working with each group.
3. Make sure that volunteers are setting up for the initial observation. Details of how to do this are on a picture in the volunteer boxes.
TECHNIQUE
Timers

Stopwatches are used to measure an amount of time.

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

The above stopwatch has gone for 1 hour, 12 minutes, 23 seconds and 11 fraction
of a second.

1. If 3:09:45 is seen on your stopwatch how much time has passed?
   Hours: 3 Minutes: 0 Seconds: 45 Fraction of a Second: \( \frac{11}{10} \)

2. If 0:01:07 is seen on your stopwatch how much time has passed?
   Hours: 0 Minutes: 1 Seconds: 7 Fraction of a Second: \( \frac{1}{6} \)

How to use a stopwatch:
1. If stopwatch is off, push the blue button to turn it on.
2. If you do not see 0:00:00 then push the blue button again to reset the stopwatch.
3. To start the stopwatch push the yellow button.
4. To stop the stopwatch push the yellow button again.
5. Record time to the nearest fraction of a second.
6. To reset to 0:00:00 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 lead to unstrap/unplug their lab coat? \( \frac{2}{6} \) s
2. How long does it take the SciTrek leader to jump three times? \( \frac{1}{5} \) s

OBSERVATIONS

Experimental Set-up:
- 3 ramps - one covered in shag carpet and one in outdoor carpet
- ball circumference = 2.7 cm
- ramp height = 15 cm
- ruler
timer
- plastic ball (green)
- ball mass = 200 g
- the second board is 183 cm from the top of the ramp

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{5}{10} )</td>
<td>( \frac{0}{10} )</td>
</tr>
<tr>
<td>1</td>
<td>( \frac{1}{10} )</td>
<td>( \frac{3}{10} )</td>
</tr>
<tr>
<td>2</td>
<td>( \frac{4}{10} )</td>
<td>( \frac{1}{10} )</td>
</tr>
<tr>
<td>3</td>
<td>( \frac{5}{10} )</td>
<td>( \frac{1}{10} )</td>
</tr>
<tr>
<td>4</td>
<td>( \frac{6}{10} )</td>
<td>( \frac{2}{10} )</td>
</tr>
</tbody>
</table>

Smallest --- Largest

Shag Carpet (s) | Outdoor Carpet (s)
----------------|-------------------
\( \frac{5}{10} \) | 0.10
\( \frac{1}{10} \) | 0.10
\( \frac{1}{10} \) | 0.10
\( \frac{1}{10} \) | 0.10

Minimum | Median | Maximum
**Introduction:** (2 minutes – Full Class – SciTrek Lead)

- Introduce the module/SciTrek volunteers.

**Question Assessment:** (5 minutes – Full Class – SciTrek Lead)

- Pass out assessments.
- Read each question and have students circle if the question is testable/not testable.
- Collect assessments.

**Technique:** (10 minutes – Full Class – SciTrek Lead)

- Have volunteers pass out notebooks.
- Have students fill out the front cover of their notebook.
- Introduce the class question (What variables affect ball motion?) and discuss why/how scientists would investigate the question.
- Tell students how to read a timer and fill out question 1 as a class and then have students fill out question 2 by themselves before reviewing.
- Have volunteers pass out timers.
- Tell them how to use a timer and then have students time you unsnapping and snapping your lab coat and jumping 3 times. Compare results to times a SciTrek volunteer gets.

**Observation Discussion:** (2 minutes – Full Class – SciTrek Lead)

- Review the definition of an observation (a description using your five senses).
- Have students move to their groups.
  - 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)

- Walk around and help groups that are struggling.
- Make sure that groups are moving along and only spending ~10 minutes on the experimental set-up and then starting to roll the ball down the two ramp materials.
- Write down groups’ median times on the class data sheet. (page 1, picture packet)

**Reproducibility Discussion**: (8 minutes – Full Class – SciTrek Lead)

- Have groups share what they did/learned.
  - Balls were rolled down outdoor carpet and sag carpet ramps. The ball hit the board first on the carpet ramp.
- Show students the class data sheet (page 1, picture packet) and have them brainstorm why groups got different times.
- Discuss the importance of repeating measurements.
- Introduce median (the middle number) and have students find the median of the collected data.
- Have students tell you how what they learned relates to the class question (the smoother the surface the less time the ball takes to hit the board).

**Variable Discussion**: (2 minutes – Full Class – SciTrek Lead)

- Review the definition of a variable (something in an experiment that can be changed).
- Explore one possible changing variable with the class and have students share why/how this variable might affect ball motion.

**Variables**: (13 minutes – Groups – SciTrek Volunteers)

- Walk around and help groups that are struggling.
- Make sure volunteers are having their group come up with possible variables as well as how/why these variables might affect ball motion.

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

- Have each group share one variable with the class and how/why they think it will affect ball motion.

**Day 2: Question Activity/Questions/Materials Page/Experimental Set-Up**

**Schedule**: You are responsible for **BOLD** sections

- 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**
Preparation:

1. If the classroom has a document camera, ask the teacher to use it for the question activity (page 3, student notebook).
2. Have volunteers set out the notebooks.
   a. If students are not in the classroom before SciTrek starts have volunteers set out the notebooks where students should sit as they come into the class.
   b. If students are in the classroom before SciTrek starts have volunteers set out the notebooks where they want students to sit and students will move to these spots after the introduction.

SciTrek Notebook Pages, Notepad Pages, and Materials Pages:

![Scientific Practices Testable Questions](image)
**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 run four trials.
2. For each trial you must measure the time the ball travels (time from ball release to ball hitting the board).
3. You will only have access to the materials on the materials page.

**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?

Changing Variable: **ball mass**

Why do you think your changing variable will affect ball motion?

I predict that heavier balls will take less time to hit the board because the heavier ball can pick up more speed.
**Introduction:** (2 minutes – Full Class – SciTrek Lead)

- If needed have SciTrek volunteers set out notebooks.
- Review the class question and what they learned last SciTrek visit.
- If needed have students move to their notebook.
**Question Activity**: (20 minutes – Full Class – SciTrek Lead)

- Ask students what type of questions can be tested by science?
  - Questions that involve things that are measurable/countable or observable.
- Ask students what type of questions cannot be tested by science? Then review categories.
  - Questions in which you **cannot acquire the data**.
  - Questions that contain **opinions or are not well defined**.
    - Opinion questions contain opinion words such as prettier, nicest, better, etc.
    - Not well defined questions contain words such as affected, react, etc.
    - Not well defined questions can contain semi-measurable words such as big, wide, heavy, etc. Example: Is the Golden Gate Bridge wide?
- Read the directions on page 3 and have students work by themselves for ~3 minutes to circle if questions are testable/not testable.
- Review each question and box the correct answer. In addition:
  - For testable questions, have students identify what data they would need to collect to answer the question.
  - For questions not testable by science, have students identify why the question is not testable and if applicable underline the word that make the question not testable, then have students revise the question to be testable.

- **Number 1**: How much does an astronaut’s suit weigh?
  - *Testable (Easy to Test-Measurement)*
  - Data: Use a scale to weigh suit
- **Number 2**: Do dogs **like** Astronaut Ice Cream?
  - *Not Testable (Opinion/Not Well Defined-Contains the Word Like)*
  - Revised: Which food do dogs eat first, Astronaut Ice Cream or steak?
- **Number 3**: Is Venus **prettier** than Saturn?
  - *Not Testable (Opinion/Not Well Defined-Opinion Comparison)*
  - Revised: Which planet has more rings, Venus or Saturn?
- **Number 4**: How many moons orbit around Jupiter?
  - *Testable (Easy to Test-Counting)*
  - Data: Count the number of moons that orbit around Jupiter.
- **Number 5**: Which planet, other than Earth, is the most **habitable**?
  - *Not Testable (Opinion/Not Well Defined-Contains an Opinion/Not Well Defined Word)*
  - Revised: 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-Fictional Character)*
  - Revised: What is the speed of the average space shuttle?
- **Number 7**: How long does it take light from the Sun to reach the Earth?
  - *Testable (Hard to Test)*
  - Data: Measure the time it takes for light from the Sun to reach the Earth.
- **Number 8**: Is the space shuttle **big**?
  - *Not Testable (Opinion/Not Well Defined-Semi Measurable)*
  - Revised: 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 (Opinion/Not Well Defined-Students Think the Answer is Yes)*
  - Revised: Does studying the solar system increase the number of planets people can name?
- **Number 19**: What color light do stars give off?
  - *Testable (Easy to Test-Observation)*
  - Data: Observe stars and determine the color light they give off.
**Question Discussion: (3 minutes – Full Class – SciTrek Lead)**

- Show the students the question frame on one of the group notepads and explain how it is used.
  - If I change _______ variable _______ what will happen to _______ what you are measuring/observing _______?

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

- Walk around and help groups that are struggling.

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

- Have one student from each group share one of their testable questions with the class.
- Have the other students identify if the question is testable or not as well as the data that would need to be collected to answer the question.
- Review the categories of questions science cannot answer:
  - Category 1: Questions in which data cannot be acquired.
  - Category 2: Questions that contain words that are opinions or are not well defined.

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

- Walk around and help groups that are struggling.

**Question/Experimental Set-Up Discussion: (3 minutes – Full Class – SciTrek Lead)**

- Have one student from each group share a question that science cannot answer.
- Have the other students identify if the question is testable or not as well as why the question is not testable.
- Tell students they will get to pick a question to design an experiment to answer.
- Go over the option for variables that students can change and show them the example materials: ball mass, ball circumference, ramp length, ramp height, and run length.
- Go over experimental considerations with students
  - You will only have access to the materials on the materials page.
  - You will run four trials.
  - For each trial you must measure the time the ball travels (time from ball release to ball hitting the board).

**Question: (4 minutes – Groups – SciTrek Volunteers)**

- Walk around and help groups that are struggling.
- Try to encourage groups to pick different changing variables.
- After students pick their changing variable, students should explain to their volunteer how they think changing this variable will affect ball motion.

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

- Walk around and help groups that are struggling.
- Make sure groups fill out the materials page correctly and completely.
**Experimental Set-Up: (5 minutes – Groups – SciTrek Volunteers)**

- Walk around and help groups that are struggling.
- Make sure that all control blanks are filled out.

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

- Have one student from each group share the question that they will investigate.
- Tell students what they will do next time.

**Day 3: Procedure/Results Table/Technique/Experiment**

**Schedule:** You are responsible for BOLD sections

- **Introduction (SciTrek Lead) – 3 minutes**
  - Procedure (SciTrek Volunteers) – 18 minutes
  - Results Table (SciTrek Volunteers) – 5 minutes

- **Technique (SciTrek Lead) – 7 minutes**
  - Experiment (SciTrek Volunteers) – 25 minutes

- **Wrap-Up (SciTrek Lead) – 2 minutes**

**Preparation:**

1. If the classroom has a document camera, ask the teacher to use it for the technique discussion (page 7, student notebook).
2. Have volunteers set out the materials that their group will use on an area on the floor.
3. Have volunteers set out the notebooks.
   a. If students are not in the classroom before SciTrek starts have volunteers set out the notebooks where students should sit as they come into the class.
   b. If students are in the classroom before SciTrek starts have volunteers set out the notebooks where they want students to sit and students will move to these spots after the introduction.
PROCEDURE

1. Roll out outdoor carpet.
2. Set up ramp that is 50cm long and 22cm tall.
3. Get 27cm circumference plastic balls with masses A) 2.65g, B) 1.65g, C) .55g, D) .340g.
4. Roll balls 200cm and time.
5. Repeat.
6. Record median number for each trial.

TECHNIQUE

Median

When running multiple trials in an experiment it is necessary to find a 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):</th>
<th>Median:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styrofoam Ball</td>
<td>5.5 6.5 7.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Metal Ball</td>
<td>1.5 1.6 1.7 2.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Wooden Ball</td>
<td>3.5 4.5 5.5 6.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Plastic Ball</td>
<td>3.5 4.5 5.5 6.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Extra Practice

An experimenters wanted to see the time it would take for a ball to hit the ground when dropped from different heights. In order for the experimenters to plot the data they need the median number. Can you help the experimenters find the median number for each height at which the ball was dropped?

<table>
<thead>
<tr>
<th>Ball Drop Height:</th>
<th>Time Ball Takes to Hit Ground (s):</th>
<th>Median:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 meters</td>
<td>10.5 10.5 10.5 10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>20 meters</td>
<td>20.5 20.5 20.5 20.5 20.5</td>
<td>20.5</td>
</tr>
<tr>
<td>30 meters</td>
<td>30.5 30.5 30.5 30.5 30.5</td>
<td>30.5</td>
</tr>
</tbody>
</table>
Introduction: (3 minutes – Full Class – SciTrek Lead)

- If needed have SciTrek volunteers set out notebooks.
- Review class question and what they did last time.
- Tell students that today they will write a procedure for their experiment and then carry out the experiment.
- If needed have students move to their notebooks

Procedure: (18 minutes – Groups – SciTrek Volunteers)

- Walk around and help groups that are struggling.
- Make sure procedures are not too long but include all values of the changing variable, controls, and what data will be collected.
- Volunteers should be writing one step and having students copy that step before moving on to the next step.

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

- Walk around and help groups that are struggling.
- Make sure that control values are written in trial A with a line through the rest of the trials and that changing variable values are written in each trials box.
**Technique:** (7 minutes – Full Class – SciTrek Lead)

- Once the first group has finished their results table, do the technique discussion.
- Review why scientists do multiple trials and what number they will use to represent all the trials. (median)
- Review how to find the median.
- Have students find the median on the top data set of page 7.
- Tell students if they have extra time, they should find the median of the bottom data set. Show students that the bottom data set numbers are not in order.

**Experiment:** (25 minutes – Groups – SciTrek Volunteers)

- Walk around and help groups that are struggling.
- Students should leave their notebooks at their desk during the experiment.
- All measurements will be recorded in the group notepad.
  - Make sure that times for each trial are entered into the group notepad from smallest to largest.
- Groups should be finding the median and recording it on the group notepad for each trial before moving onto the next trial.
- Students will move back to their desks and copy only the median number from each trial into their notebooks.

**Wrap-Up:** (2 minutes – Full Class – SciTrek Lead)

- Tell students what they will do next time.

**Day 4: Graph/Results Summary/Poster Making**

**Schedule:** You are responsible for **BOLD** sections

- **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

**Preparation:**

1. Ask the classroom teacher for a place to leave the student posters.
2. Have volunteers set out notebooks.
   a. If students are not in the classroom before SciTrek starts have volunteers set out the notebooks where students should sit as they come into the class.
   b. If students are in the classroom before SciTrek starts have volunteers set out the notebooks where they want students to sit and students will move to these spots after the introduction.
My experiment shows that ball mass does not affect the time the ball takes to hit the board because the ~140g ball took 1 1/2 s and the ~380g ball took 1 1/2 s to hit the board as well.
Introduction: (2 minutes – Full Class – SciTrek Lead)

- If needed have SciTrek volunteers set out notebooks.
- Review the class question.
- Tell students that toady they are going to graph their data and making a poster.
- If needed have students move to their notebooks.

Graph: (10 minutes – Groups – SciTrek Volunteers)

- Walk around and help groups that are struggling.
- Make sure that students are graphing their trial on the individual graph piece with the value of the changing variable written underneath.
- Make sure volunteers are having students arrange the individual graph pieces in increasing order by time and then taping them onto the group notepad.
- Make sure students are writing the time on top of each column.

Results Summary: (10 minutes – Groups – SciTrek Volunteers)

- Walk around and help groups that are struggling.
- Make sure that groups are generating a claim (ideally the claim will allow them to make a prediction about future experiments) and using data to back it up.
  - Do not reference trial letters in results summary
- Volunteers struggle with results summaries, therefore, try to check each group’s results summary.
- Have students fill out the sentence frame on page 10, “I acted like a scientist when ______.”

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

- Help volunteers glue poster pieces onto the poster. When gluing, make sure that the volunteers are gluing the poster in the exact order that is shown on the diagram and that the poster has a landscape orientation.
- Make sure that the student in each group who is presenting the results graph has the appropriate sentence frame sticker in their notebook and the volunteer has gone over how to present the four sentences with the student several times.
- Each student should have the part(s) that they are presenting highlighted and numbered in their notebook. (1) scientists’ names, 2) question, 3) experimental set-up, 4) procedure, 5) results graph, and 6) results summary.) (see pictures above)
Wrap-Up: (5 minutes – Full Class – SciTrek Lead)

- Ask students the following questions:
  o How did you act like a scientist during this project?
  o What did you do that scientists do?

Day 5: Poster Presentations

Schedule: You are responsible for **BOLD** sections

**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

Preparation:

1. If the classroom has a document camera, ask the teacher to use it for the notes on presentations (page 0-2, picture packet). If there is no document camera write the class question on the board.
2. Give the teacher the “Evaluation of the SciTrek Program by Participating Teachers” form. Ask teachers to fill this form out and give it back to you the next time you are there.
3. Organize posters so that experiments about the same changing variable will be presented back to back.
4. Have volunteers pass out notebooks.

SciTrek Picture Packet Page:

![Picture Packet](image_url)
Introduction: (2 minutes – Full Class – SciTrek Lead)

- If needed have SciTrek volunteers pass out notebooks.
- Tell students that they will have 15 minutes to discuss their experiment and practice their posters.
- DO NOT GIVE STUDENTS MORE THAN 15 MINTES OR YOU WILL RUN OUT OF TIME FOR POSTERS.

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

- Organize posters so that experiments about the same changing variable are presented back to back.
- Make sure that volunteers are having students explain their experiment and asking them questions that make them generate predictions based on their data.
- Make sure students are reading from their notebook and practicing the poster in the following order: 1) scientists’ names, 2) question, 3) experimental set-up, 4) procedure, 5) results graph, and 6) results summary. They will NOT read the “I acted like a scientist when _______,” or results table from their poster.

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

- Have students present their posters.
- While posters are being presented, record each group’s changing variable values and data on page 2 of the picture packet.
  - When a group reads their question, record the changing variable.
  - Stop the presentation after the question and have the class identify the changing variable.
  - When a group reads their graph, record the values of the changing variable and their measurements.
- After each presentation ask students:
  - What questions do you have for this group?
  - Can someone summarize what we learned from this group?
- Record what they learned under the summary on page 2 of the picture packet.
- After all presentations are over, have students tell you the variable values that they would select to have a ball hit a board in the least amount of time.

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 SciTrek volunteers, therefore, they should say goodbye to them.
- Tell students to remove the paper part of their nametag from the plastic holder and that they can keep the paper nametag but need to give the plastic holder back to their SciTrek volunteer.

Day 6: Question Assessment/Tie to Standards/Content Assessment

Schedule: You are responsible for BOLD sections

Question Assessment (SciTrek Lead) – 10 minutes
Tie to Standards (SciTrek Lead) – 40 minutes
Content Assessment (SciTrek Lead) – 10 minutes
**Preparation:**

1. Collect the “Evaluation of the SciTrek Program by Participating Teachers” from the teacher.
2. If the classroom has a document camera, ask the teacher to use it for the tie to standards activity (pages 10-12, student notebook).
3. Follow the set-up instructions below for the set-up for the tie to standards activity:
   a. Roll out the 5 ft × 2 ft carpet onto the table in the front of the class if possible. If not it can be done on the floor.
   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). Align the ramps so that the bottom of the ramps are sitting on the 50 cm mark on the carpet.
   c. Set the ball stop board at the 150 cm mark (Set-Up 1).
   d. 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).
4. Pass out the question assessments and student notebooks.
5. Remind the teacher to give you their lab coat at the end of the day.
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 a speed of an object? 
   \begin{itemize}
   \item time
   \item distance
   \end{itemize}

2. If all distances are equal, the ball that hits the board first, has \textbf{a smaller} speed.

Ramp Height

3. Fill in 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 \textbf{Tie} if the two balls tied.

<table>
<thead>
<tr>
<th>Set-Up 1</th>
<th>Set-Up 2</th>
<th>Prediction</th>
<th>Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Does the ramp height affect the speed of the ball? \textbf{YES} \textbf{NO}

5. Explain how ramp height affects the speed of the ball. 
   \textbf{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>Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball Mass: 250 g</td>
<td>Ball Mass: 350 g</td>
<td>\textbf{Tie}</td>
<td>\textbf{4 Trials}</td>
</tr>
</tbody>
</table>

7. Does the ball mass affect the speed of the ball? \textbf{YES} \textbf{NO}

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

9. Which ball do you think will hit the ground first when dropped from the same height?
   \begin{itemize}
   \item Blue Ball (250 g)
   \item Purple Ball (350 g)
   \end{itemize}
   \textbf{The Balls Will Tie}

10. Which ball hits the ground first? \textbf{The balls tied}

Run Material

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

<table>
<thead>
<tr>
<th>Set-Up 5</th>
<th>Set-Up 6</th>
<th>Prediction</th>
<th>Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Material: Turf</td>
<td>Run Material: Wood</td>
<td>\textbf{Tie}</td>
<td>\textbf{5 Trials}</td>
</tr>
</tbody>
</table>

12. Does the run material affect the speed of the ball? \textbf{YES} \textbf{NO}

13. Explain how run material affects the speed of the ball. 
   \textbf{The smoother the run material, the faster the ball.}

Is motion predictable?

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

<table>
<thead>
<tr>
<th>Variables</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Height</td>
<td>Either</td>
<td>Either</td>
<td>Either</td>
</tr>
<tr>
<td>Ball Mass</td>
<td>100 g</td>
<td>1000 g</td>
<td>Either</td>
</tr>
<tr>
<td>Run Material</td>
<td>Sand Paper</td>
<td>Flat</td>
<td>Either</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Variables</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Height</td>
<td>Either</td>
<td>Either</td>
<td>Either</td>
</tr>
<tr>
<td>Ball Mass</td>
<td>1 g</td>
<td>10 g</td>
<td>Either</td>
</tr>
<tr>
<td>Run Material</td>
<td>Turf</td>
<td>Cardboard</td>
<td>Either</td>
</tr>
</tbody>
</table>
Question Assessment: (10 minutes – Full Class – SciTrek Lead)

- Pass out assessments.
- Read each question and have students circle if the question is testable/not testable.
- On the back of the question assessment, have students answer the questions at the bottom of the page before drawing a picture.
- Collect assessments.

Tie to Standards: (40 minutes – Full Class – SciTrek Lead)

- Tell the class that their experiments have taught you a lot about ball motion and today we will review some of the variables that affect ball motion.

Speed vs. Time (5 minutes)

- Have students fill in the measurements that are needed to get speed, question 1.
- Have students circle the relative speed of the ball that hits the board first, question 2.

Effects of Ramp Height (10 minutes)

- Show student the two different ramp heights and have them predict which ramp height will cause the ball to hit the board first.
- Roll the balls down both ramps at the same time and record which ball hits the board first. Repeat this process three times.
- Have students fill out questions 4 and 5.
  IMPORTANT: While students are writing, 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).
- Discuss what happens if the ramp height is above 45°.
  - the time it take to hit the board will go up because although the ball will have more energy the energy will be directed more downwards instead of towards the ball stop board.

Effects of Ball Mass (10 minutes)

- Show students the two balls with different masses (~265 g (light blue ball) and ~360 g (purple ball)) and have them predict which ball will hit the board first.
- Roll the balls down both the ramp at the same time and record which ball hits the board first. Repeat this process three times.
- Have students fill out questions 7 and 8.
  IMPORTANT: While students are writing, 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).
- Have students predict which ball (light blue or purple) will hit the board first when dropped, question 9.
- Drop both balls on the wooden ramp so that they can hear that both balls hit the wood at the same time.
- Have students fill out which ball hit the ground first, question 10.
Effect of Run Material (10 minutes)

- Show students the two different run materials and have them predict which run material will cause the ball to hit the board first.
- Roll the balls down both ramps at the same time and record which ball hits the board first. Repeat this process three times.
- Have students fill out questions 12 and 13.

Motion Predictability (5 minutes)

- Ask students if ball motion is predictable.
- Have students select values that would cause the ball to travel at the greatest speed, question 14(a).
- Have students select values that would cause the ball to travel at the slowest speed, question 14(b).
- Review how all variables affect ball motion.

Content Assessment: (10 minutes – Full Class – SciTrek Lead)

- Pass out content assessments.
- Read each question to students.
- Collect content assessments.

Extra Practice Solutions:

![Extra Practice Solutions](image)