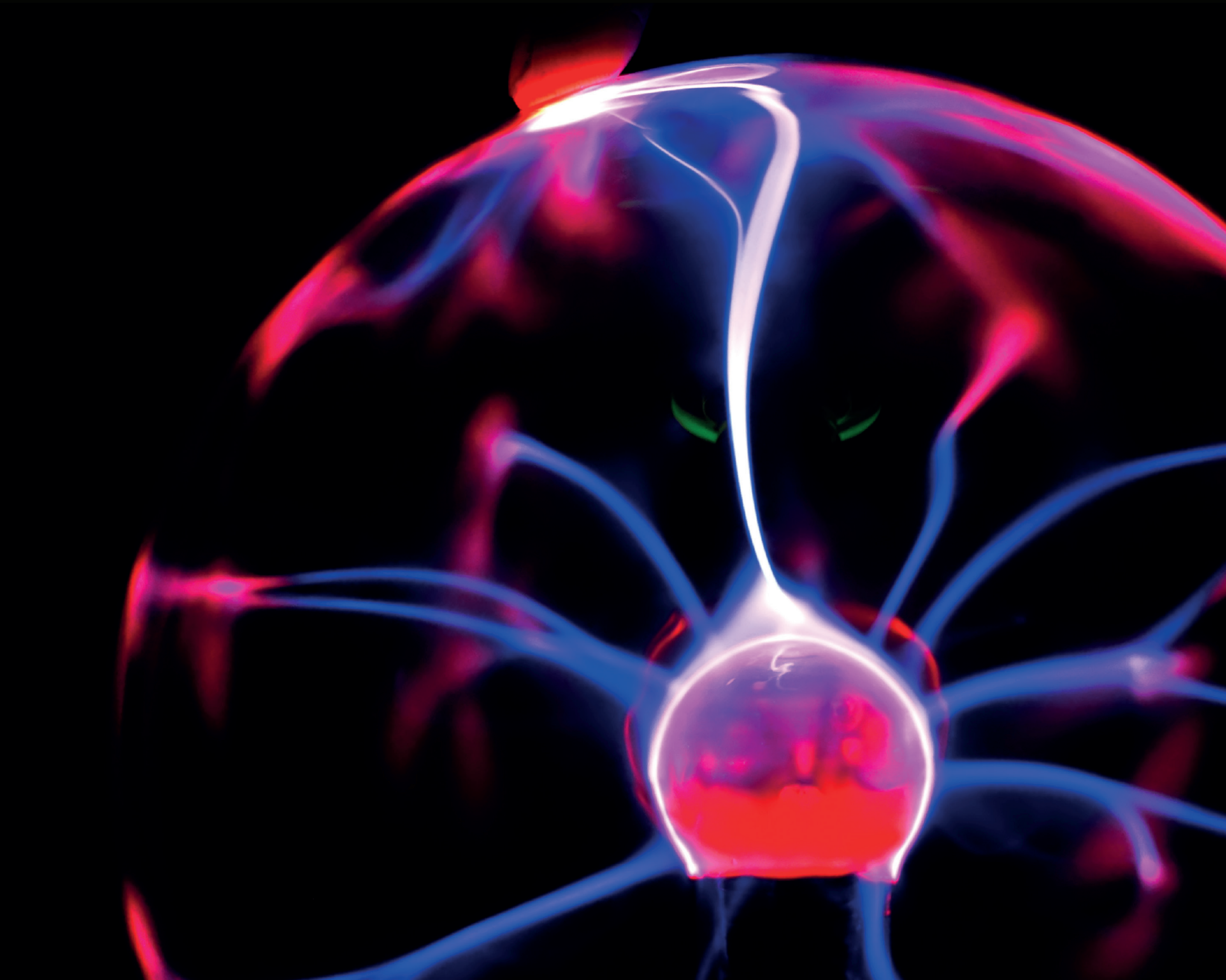
BIOZONE

CLASSROOM GUIDE

PHYSICAL SCIENCES FOR NGSS



Contents

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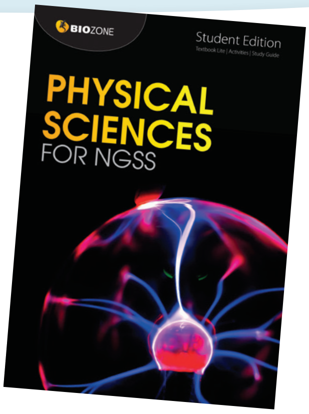
FAQs ABOUT PHYSICAL SCIENCES FOR NGSS



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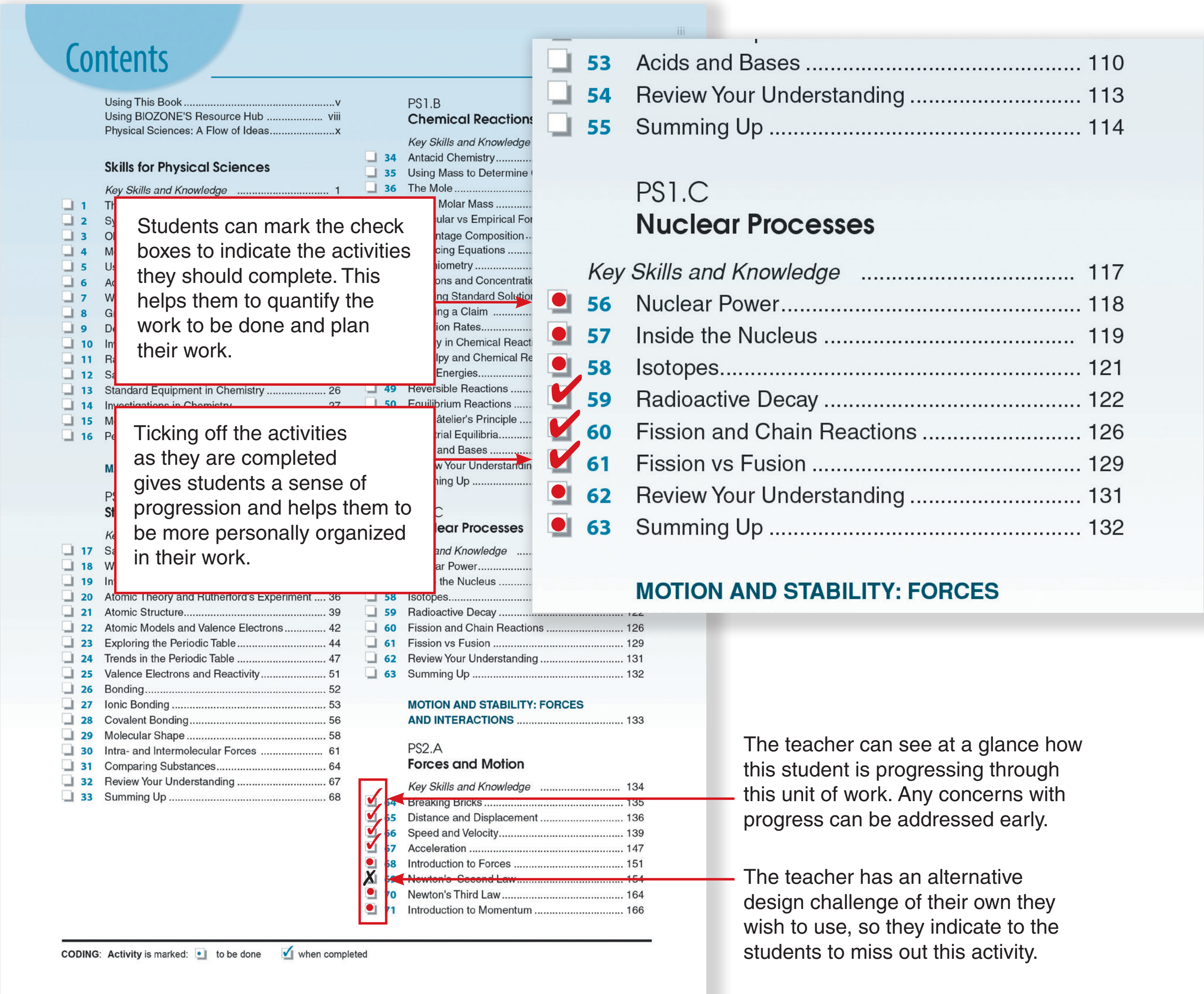
The Contents: A Planning Tool

The contents pages are not merely a list of the activities in the student edition. Encourage your students to use them as a planning tool for their program of work. Students can identify the activities they are to complete and then tick them off when completed. The teacher can also see at a glance how quickly the student is progressing through the assigned material.



What about a pacing guide?

The 9-12 NGSS framework is fluid in terms of the grade in which each program is offered, so in many respects defies a rigid pacing guide. Within grade, other variables contribute to changes in pacing:

- There are opportunities for students to spend longer on some activities (e.g. in improving or refining their design solutions or in exploring simulations beyond the minimum). These elaborations will demand more time.
- The time allocated for investigations will depend on (1) how you choose to organize the class (which may be determined by available resources) and (2) how far students take the investigation. Adjust your lesson plan to incorporate more or less material as needed. You may have investigations you already like to use, so you could choose to leave out equivalent investigations in the book.
- For computer modeling activities, completed models are available on **BIOZONE's Resource Hub** and the Teacher's Digital Edition, so students can save time by exploring the model, but not building it themselves.
- The pace may quicken as students complete more of the book. Later chapters draw on knowledge and understanding of previous chapters, as well as exploring new concepts. Students gain increasing levels of competence and learn valuable skills that enable them to arrive at solutions more quickly. That aside, teachers may appropriately choose to do the physics block of chapters before chemistry.

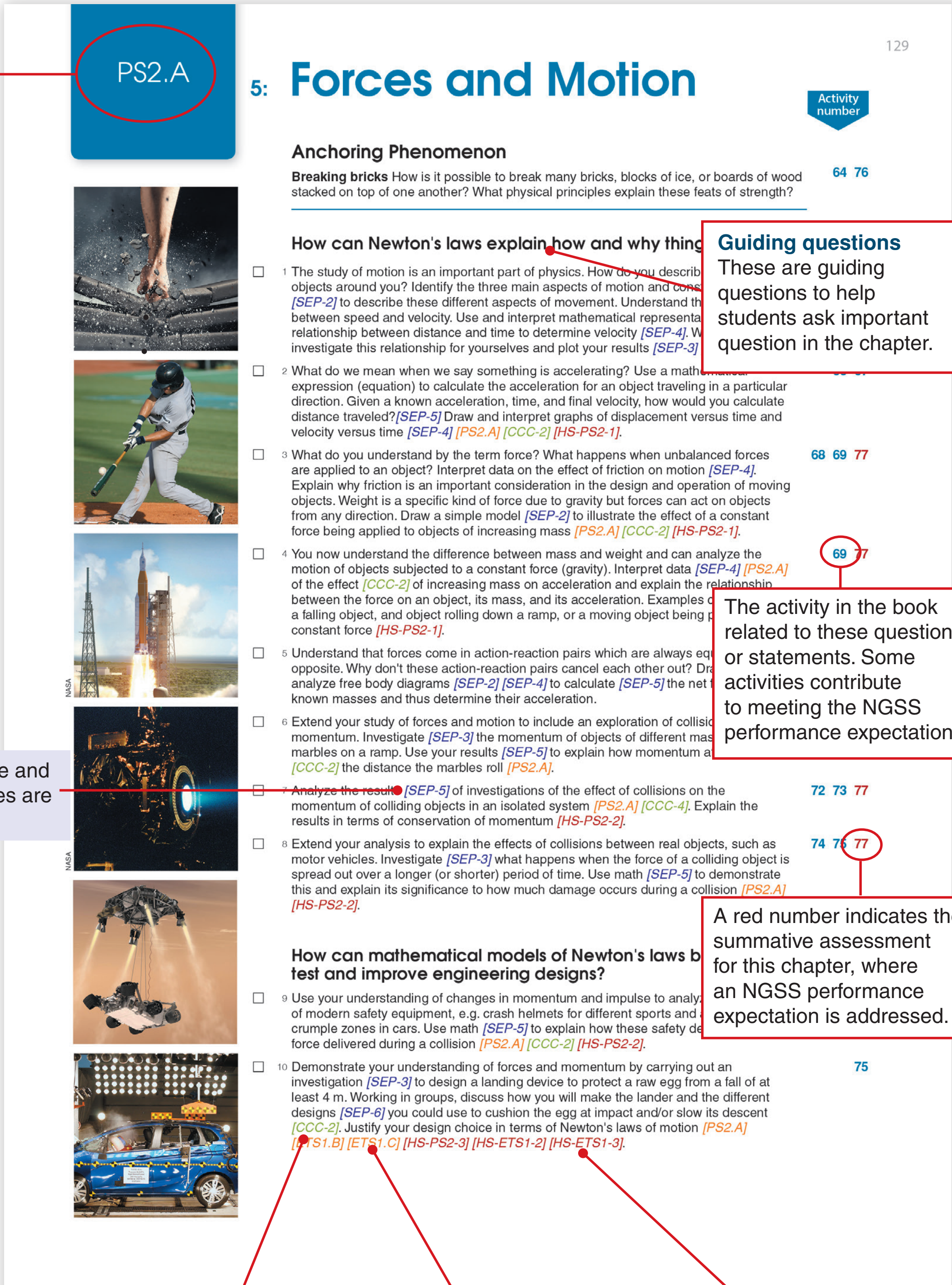
Identifying Learning Intentions and Goals

In developing *Physical Sciences for NGSS*, we have embraced the three dimensions of the NGSS framework, emphasizing the application of ideas and skills to new scenarios. The activities in *Physical Sciences for NGSS* have been specifically designed to address the **disciplinary core ideas (DCIs), science and engineering practices, and crosscutting concepts** in a way that helps students to meet specific performance expectations.

In the Teacher's Edition and Teacher's Digital Edition, all three dimensions are embedded in the text and color coded for easy identification (below). The performance expectations are also identified. It is important to note that *this coding is a tool for the teacher and is not present in the Student Edition*.

This identifies the DCI(s) to which this chapter applies.

The relevant science and engineering practices are indicated in **blue**.


PS2.A

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5: Forces and Motion

Activity number

Anchoring Phenomenon

Breaking bricks How is it possible to break many bricks, blocks of ice, or boards of wood stacked on top of one another? What physical principles explain these feats of strength? 64 76

How can Newton's laws explain how and why thing

1 The study of motion is an important part of physics. How do you describ objects around you? Identify the three main aspects of motion and cons [SEP-2] to describe these different aspects of movement. Understand th between speed and velocity. Use and interpret mathematical representa relationship between distance and time to determine velocity [SEP-4]. W investigate this relationship for yourselves and plot your results [SEP-3]

2 What do we mean when we say something is accelerating? Use a math expression (equation) to calculate the acceleration for an object traveling in a particular direction. Given a known acceleration, time, and final velocity, how would you calculate distance traveled? [SEP-5] Draw and interpret graphs of displacement versus time and velocity versus time [SEP-4] [PS2.A] [CCC-2] [HS-PS2-1].

3 What do you understand by the term force? What happens when unbalanced forces are applied to an object? Interpret data on the effect of friction on motion [SEP-4]. Explain why friction is an important consideration in the design and operation of moving objects. Weight is a specific kind of force due to gravity but forces can act on objects from any direction. Draw a simple model [SEP-2] to illustrate the effect of a constant force being applied to objects of increasing mass [PS2.A] [CCC-2] [HS-PS2-1]. 68 69 77

4 You now understand the difference between mass and weight and can analyze the motion of objects subjected to a constant force (gravity). Interpret data [SEP-4] [PS2.A] of the effect [CCC-2] of increasing mass on acceleration and explain the relationship between the force on an object, its mass, and its acceleration. Examples c a falling object, and object rolling down a ramp, or a moving object being p constant force [HS-PS2-1]. 69 77

5 Understand that forces come in action-reaction pairs which are always eq opposite. Why don't these action-reaction pairs cancel each other out? Dr analyze free body diagrams [SEP-2] [SEP-4] to calculate [SEP-5] the net f known masses and thus determine their acceleration.

6 Extend your study of forces and motion to include an exploration of collisio momentum. Investigate [SEP-3] the momentum of objects of different mas marbles on a ramp. Use your results [SEP-5] to explain how momentum a [CCC-2] the distance the marbles roll [PS2.A].

7 Analyze the results [SEP-5] of investigations of the effect of collisions on the momentum of colliding objects in an isolated system [PS2.A] [CCC-4]. Explain the results in terms of conservation of momentum [HS-PS2-2]. 72 73 77

8 Extend your analysis to explain the effects of collisions between real objects, such as motor vehicles. Investigate [SEP-3] what happens when the force of a colliding object is spread out over a longer (or shorter) period of time. Use math [SEP-5] to demonstrate this and explain its significance to how much damage occurs during a collision [PS2.A] [HS-PS2-2]. 74 75 77

How can mathematical models of Newton's laws b test and improve engineering designs?

9 Use your understanding of changes in momentum and impulse to analyz of modern safety equipment, e.g. crash helmets for different sports and crumple zones in cars. Use math [SEP-5] to explain how these safety de force delivered during a collision [PS2.A] [CCC-2] [HS-PS2-2].

10 Demonstrate your understanding of forces and momentum by carrying out an investigation [SEP-3] to design a landing device to protect a raw egg from a fall of at least 4 m. Working in groups, discuss how you will make the lander and the different designs [SEP-6] you could use to cushion the egg at impact and/or slow its descent [CCC-2]. Justify your design choice in terms of Newton's laws of motion [PS2.A] [ETS1.B] [ETS1.C] [HS-PS2-3] [HS-ETS1-2] [HS-ETS1-3]. 75

Guiding questions These are guiding questions to help students ask important question in the chapter.

The activity in the book related to these questions or statements. Some activities contribute to meeting the NGSS performance expectations.

A red number indicates the summative assessment for this chapter, where an NGSS performance expectation is addressed.

The relevant crosscutting concepts are indicated in **green**.

The relevant disciplinary core are indicated in **orange**.

The relevant performance expectation is indicated in **red**

Scaffolded Learning with the 5 Es

In developing *Physical Sciences for NGSS* we have utilized the 5Es instructional model as a basis for developing materials to address all three dimensions of the NGSS framework: **disciplinary core ideas** (DCIs), **science and engineering practices**, and **crosscutting concepts**. By successfully completing the activities, students can demonstrate competence in all three dimensions. This is central to meeting the performance expectations for *Physical Sciences for NGSS* with confidence.

BIOZONE encourages the development of the NGSS learner profile using the 5Es model

The Five Es

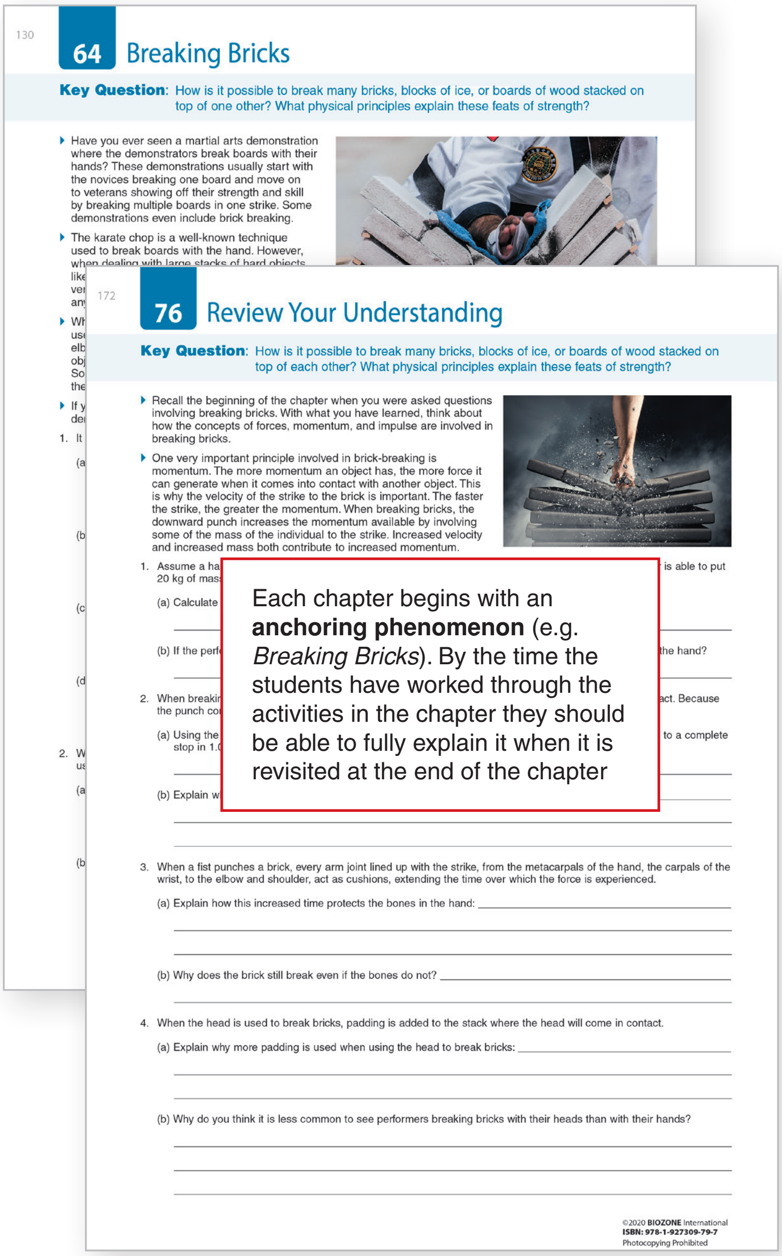
Engage:	make connections between past and present learning experiences.
Explore:	become actively involved in the activity.
Explain:	communicate the learning experience.
Elaborate:	expand on the concepts learned.
Evaluate:	assess understanding of the concepts.

BIOZONE's series for NGSS is **phenomenon-based**. Students engage with phenomena through their own investigations and observations, through modeling and data analysis, and through collaborative work and discussion.

Using phenomena to drive inquiry promotes discussion and the sharing of ideas. The iterative approach presents opportunities to look at phenomena from several different perspectives. This allows students of all abilities to expand their thinking and understanding, increasing understanding each time the phenomenon is revisited.

Each chapter begins with an **anchoring phenomenon** (right). In each instance, we have chosen a phenomenon that the student is probably familiar with, but which they cannot explain (or cannot explain fully). Teachers can use this activity to find out what the students already know (or think they know) before delving into the content more fully.

The subsequent activities in a chapter take the students, step by step, through phenomena that explore the ideas inherent in the anchoring phenomenon. By the time students revisit the anchoring phenomenon, they should be able to fully explain it.



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64 Breaking Bricks

Key Question: How is it possible to break many bricks, blocks of ice, or boards of wood stacked on top of one other? What physical principles explain these feats of strength?

- Have you ever seen a martial arts demonstration where the demonstrators break boards with their hands? These demonstrations usually start with the novices breaking one board and move on to veterans showing off their strength and skill by breaking multiple boards in one strike. Some demonstrations even include brick breaking.
- The karate chop is a well-known technique used to break boards with the hand. However, when dealing with large stacks of hard objects ...

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76 Review Your Understanding

Key Question: How is it possible to break many bricks, blocks of ice, or boards of wood stacked on top of each other? What physical principles explain these feats of strength?

- Recall the beginning of the chapter when you were asked questions involving breaking bricks. With what you have learned, think about how the concepts of forces, momentum, and impulse are involved in breaking bricks.
- One very important principle involved in brick-breaking is momentum. The more momentum an object has, the more force it can generate when it comes into contact with another object. This is why the velocity of the strike to the brick is important. The faster the strike, the greater the momentum. When breaking bricks, the downward punch increases the momentum available by involving some of the mass of the individual to the strike. Increased velocity and increased mass both contribute to increased momentum.

1. Assume a ha... is able to put 20 kg of mas...
   (a) Calculate ...
   (b) If the perf... the hand?
2. When breakin... act. Because the punch co...
   (a) Using the ... to a complete stop in 1.0...
   (b) Explain w...
3. When a fist punches a brick, every arm joint lined up with the strike, from the metacarpals of the hand, the carpals of the wrist, to the elbow and shoulder, act as cushions, extending the time over which the force is experienced.
   (a) Explain how this increased time protects the bones in the hand: ______
   (b) Why does the brick still break even if the bones do not? ______
4. When the head is used to break bricks, padding is added to the stack where the head will come in contact.
   (a) Explain why more padding is used when using the head to break bricks: ______
   (b) Why do you think it is less common to see performers breaking bricks with their heads than with their hands?

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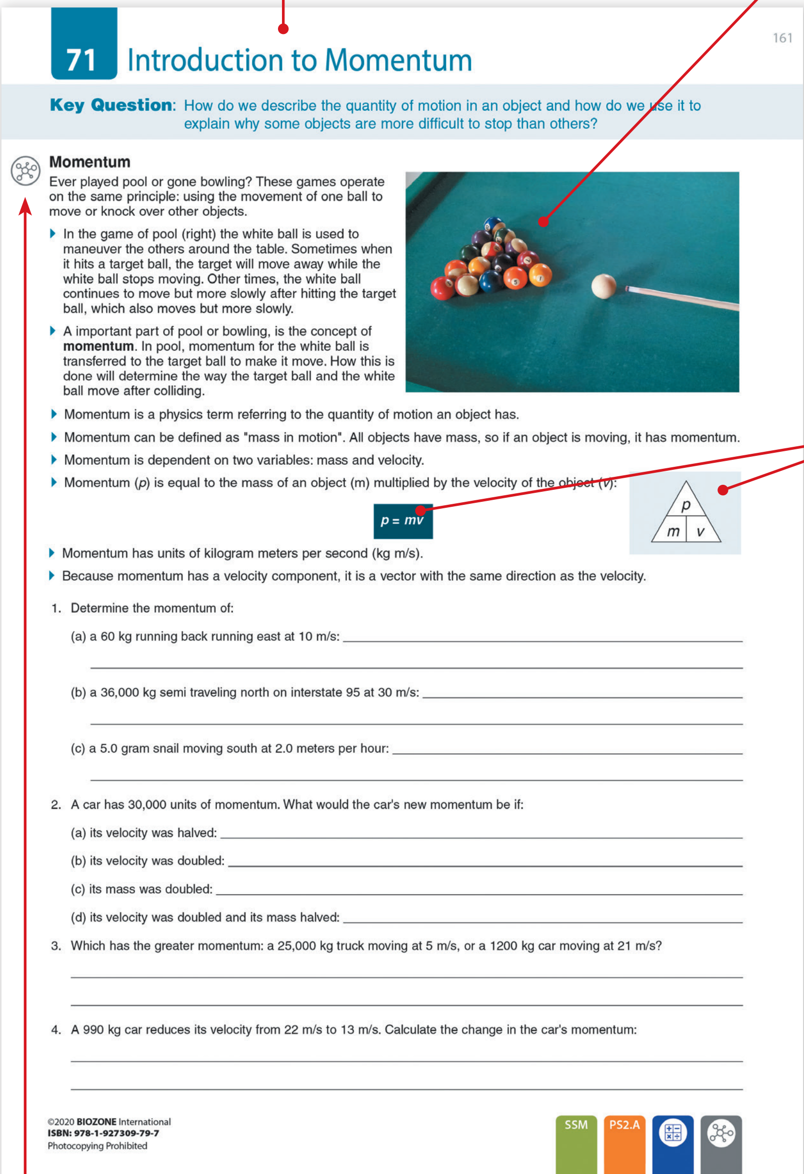
Each chapter begins with an **anchoring phenomenon** (e.g. *Breaking Bricks*). By the time the students have worked through the activities in the chapter they should be able to fully explain it when it is revisited at the end of the chapter

The content of the *Physical Sciences for NGSS* is organized into 11 chapters based on the DCIs of the High School Physical Sciences framework. Chapter 1 addresses basic skills for students in physical sciences. Chapters 2 - 11 each begin with an introduction outlining learning goals, which is immediately followed by the anchoring phenomenon. Activities make up the bulk of each chapter, with each one focusing on the student investigating and developing understanding of a phenomenon, applying that understanding to new scenarios, and developing (or practicing) a skill or essential science practice, such as graphing, data analysis, modeling, or evidence-based explanation.

Annotated diagrams and photographs are a major part of most activities and the student's understanding of the information is evaluated through questions and/or tasks involving data handling and interpretation. Tabs at the bottom of the page identify crosscutting concepts, science and engineering practices, and disciplinary core ideas as appropriate. Tabs in the margin also indicate if the activity is supported via **BIOZONE's Resource Hub**, which provides online teacher and student support for specific aspects of the activity.

Concepts are presented as a logical sequence, that may be divided among several consecutive activities. Understanding of phenomena is developed progressively through exploration and explanation.

ENGAGE with phenomena
Activities normally begin with a brief task, observation, or example to engage student thinking, allowing them to review their current understanding of a phenomenon, or providing an interesting (if not yet fully explained) piece of information that relates to the concept about to be studied. This is a chance for teachers to assess prior knowledge or engage students by posing challenging questions about seemingly simple phenomena.



71 Introduction to Momentum

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Key Question: How do we describe the quantity of motion in an object and how do we use it to explain why some objects are more difficult to stop than others?

Momentum

Ever played pool or gone bowling? These games operate on the same principle: using the movement of one ball to move or knock over other objects.

- In the game of pool (right) the white ball is used to maneuver the others around the table. Sometimes when it hits a target ball, the target will move away while the white ball stops moving. Other times, the white ball continues to move but more slowly after hitting the target ball, which also moves but more slowly.
- A important part of pool or bowling, is the concept of **momentum**. In pool, momentum for the white ball is transferred to the target ball to make it move. How this is done will determine the way the target ball and the white ball move after colliding.
- Momentum is a physics term referring to the quantity of motion an object has.
- Momentum can be defined as "mass in motion". All objects have mass, so if an object is moving, it has momentum.
- Momentum is dependent on two variables: mass and velocity.
- Momentum (p) is equal to the mass of an object (m) multiplied by the velocity of the object (v):

$$p = mv$$

- Momentum has units of kilogram meters per second (kg m/s).
- Because momentum has a velocity component, it is a vector with the same direction as the velocity.

1. Determine the momentum of:
   (a) a 60 kg running back running east at 10 m/s:
   (b) a 36,000 kg semi traveling north on interstate 95 at 30 m/s:
   (c) a 5.0 gram snail moving south at 2.0 meters per hour:
2. A car has 30,000 units of momentum. What would the car's new momentum be if:
   (a) its velocity was halved:
   (b) its velocity was doubled:
   (c) its mass was doubled:
   (d) its velocity was doubled and its mass halved:
3. Which has the greater momentum: a 25,000 kg truck moving at 5 m/s, or a 1200 kg car moving at 21 m/s?
4. A 990 kg car reduces its velocity from 22 m/s to 13 m/s. Calculate the change in the car's momentum:

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SSM PS2.A

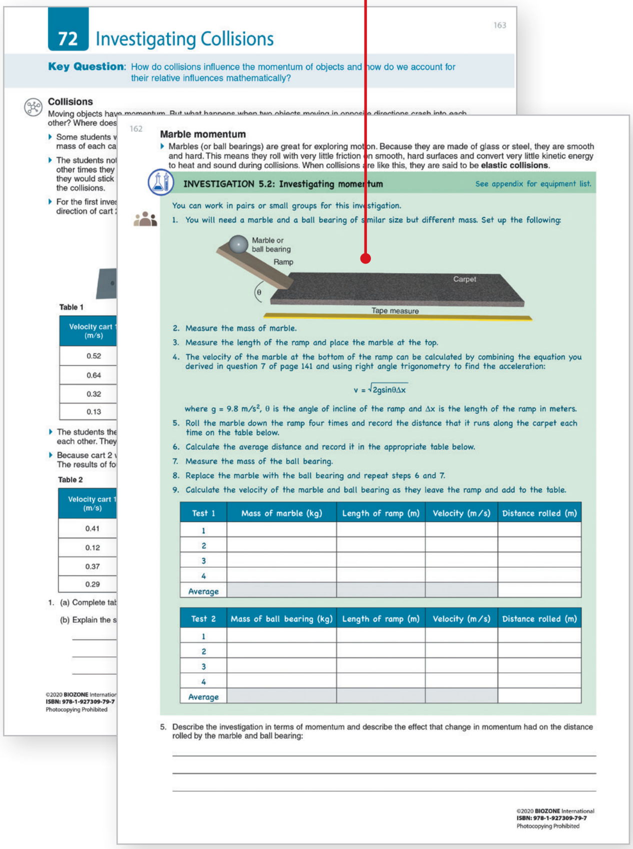
Important formulae that students should be able to understand and use are given in a dark blue box. Fact family triangles make use of these formulae simpler.

Students are given enough information to complete the activity's tasks. To progress through the activity they may need to apply knowledge and information developed earlier in the activity. Answers to questions are not always directly available on the page. Students may need to analyze data or information and draw conclusions to answer the questions and progress to the next part of the activity. Students are sometimes asked to do further research or carry out their own research or investigation.

This part of the activity also has supporting resources on **BIOZONE's Resource Hub** assigned to it.

Relevant SEPs, DCIs, and CCCs are identified through the tab system.

Students can **EXPLORE** the phenomenon via practical activities, creating their own models, analyzing or using second hand data, or interpreting diagrams. In this example, students use marbles of different mass and size to explore the concept of momentum. They also explore momentum using second-hand data of carts on an air track.


72 Investigating Collisions

Key Question: How do collisions influence the momentum of objects and how do we account for their relative influences mathematically?

Marble momentum

- Marbles (or ball bearings) are great for exploring motion. Because they are made of glass or steel, they are smooth and hard. This means they roll with very little friction on smooth, hard surfaces and convert very little kinetic energy to heat and sound during collisions. When collisions are like this, they are said to be **elastic collisions**.

INVESTIGATION 5.2: Investigating momentum — See appendix for equipment list.

You can work in pairs or small groups for this investigation.

1. You will need a marble and a ball bearing of similar size but different mass. Set up the following:
2. Measure the mass of marble.
3. Measure the length of the ramp and place the marble at the top.
4. The velocity of the marble at the bottom of the ramp can be calculated by combining the equation you derived in question 7 of page 141 and using right angle trigonometry to find the acceleration:

$v = \sqrt{2g\sin\theta\Delta x}$

where g = 9.8 m/s², θ is the angle of incline of the ramp and Δx is the length of the ramp in meters.

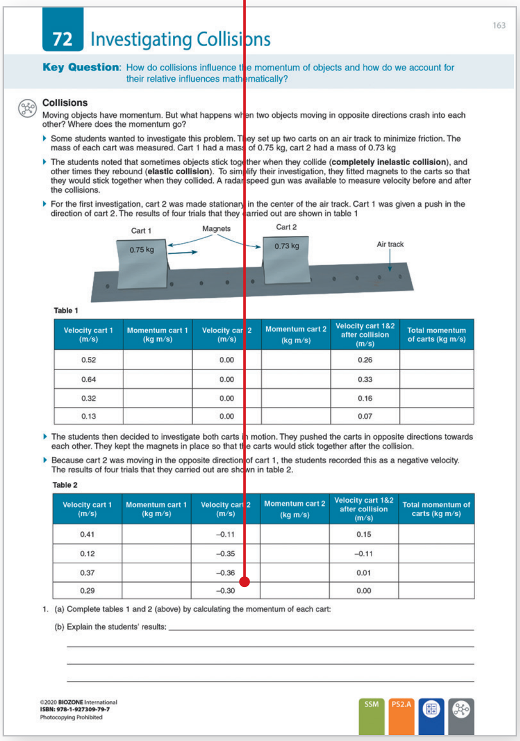
5. Roll the marble down the ramp four times and record the distance that it runs along the carpet each time on the table below.
6. Calculate the average distance and record it in the appropriate table below.
7. Measure the mass of the ball bearing.
8. Replace the marble with the ball bearing and repeat steps 6 and 7.
9. Calculate the velocity of the marble and ball bearing as they leave the ramp and add to the table.

Test 1	Mass of marble (kg)	Length of ramp (m)	Velocity (m/s)	Distance rolled (m)
1				
2				
3				
4				
Average				

Test 2	Mass of ball bearing (kg)	Length of ramp (m)	Velocity (m/s)	Distance rolled (m)
1				
2				
3				
4				
Average				

5. Describe the investigation in terms of momentum and describe the effect that change in momentum had on the distance rolled by the marble and ball bearing:

Students **EXPLAIN** phenomena by building on what they discovered through exploration. They are encouraged to use scientific principles and logical reasoning to construct explanations and devise solutions to the problems presented to them. Here students analyze data of initial and final velocities to find and explain the underlying relationship between initial and final momentum.


72 Investigating Collisions

Key Question: How do collisions influence the momentum of objects and how do we account for their relative influences mathematically?

Collisions

Moving objects have momentum. But what happens when two objects moving in opposite directions crash into each other? Where does the momentum go?

- Some students wanted to investigate this problem. They set up two carts on an air track to minimize friction. The mass of each cart was measured. Cart 1 had a mass of 0.75 kg, cart 2 had a mass of 0.73 kg
- The students noted that sometimes objects stick together when they collide (**completely inelastic collision**), and other times they rebound (**elastic collision**). To simplify their investigation, they fitted magnets to the carts so that they would stick together when they collided. A radar speed gun was available to measure velocity before and after the collisions.
- For the first investigation, cart 2 was made stationary in the center of the air track. Cart 1 was given a push in the direction of cart 2. The results of four trials that they carried out are shown in table 1

Table 1

Velocity cart 1 (m/s)	Momentum cart 1 (kg m/s)	Velocity cart 2 (m/s)	Momentum cart 2 (kg m/s)	Velocity cart 1&2 after collision (m/s)	Total momentum of carts (kg m/s)
0.52		0.00		0.26	
0.64		0.00		0.33	
0.32		0.00		0.16	
0.13		0.00		0.07	

- The students then decided to investigate both carts in motion. They pushed the carts in opposite directions towards each other. They kept the magnets in place so that the carts would stick together after the collision.
- Because cart 2 was moving in the opposite direction of cart 1, the students recorded this as a negative velocity. The results of four trials that they carried out are shown in table 2.

Table 2

Velocity cart 1 (m/s)	Momentum cart 1 (kg m/s)	Velocity cart 2 (m/s)	Momentum cart 2 (kg m/s)	Velocity cart 1&2 after collision (m/s)	Total momentum of carts (kg m/s)
0.41		–0.11		0.15	
0.12		–0.35		–0.11	
0.37		–0.36		0.01	
0.29		–0.30		0.00	

1. (a) Complete tables 1 and 2 (above) by calculating the momentum of each cart:

(b) Explain the students' results:

After sound explanations of phenomena are developed, students have opportunity to **ELABORATE**, applying their understanding to new phenomena or using their experience to develop or refine engineering solutions to relevant problems. Here students apply the concepts of momentum and impulse to design a landing device that will protect an egg from a fall.


75 Crumple Zones and Crash Helmets

Key Question: How are the principles of momentum and impulse applied to limit damage to sensitive objects and save lives?

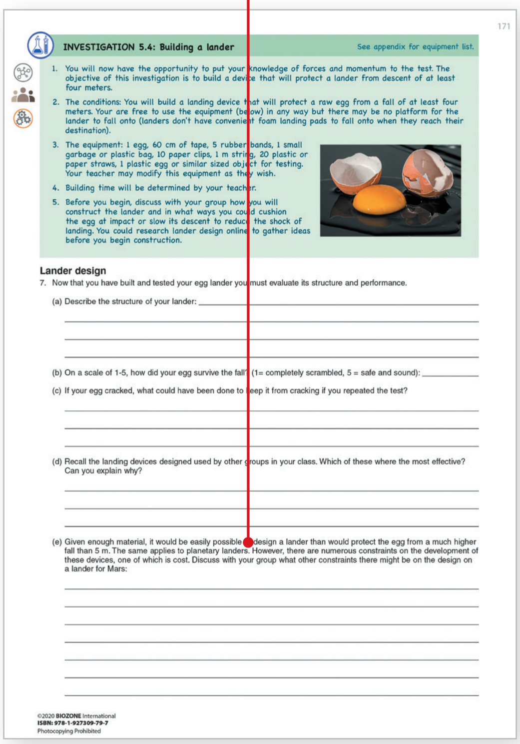
Landing on Mars

INVESTIGATION 5.4: Building a lander — See appendix for equipment list.

Lander design

7. Now that you have built and tested your egg lander you must evaluate its structure and performance.

Students **EVALUATE** their investigations. This can provide opportunities for **formative assessment** (if you wish). In this example, students evaluate their lander design and decide if there are any improvements that could be made. There is opportunity here for peer assessment.


INVESTIGATION 5.4: Building a lander — See appendix for equipment list.

1. You will now have the opportunity to put your knowledge of forces and momentum to the test. The objective of this investigation is to build a device that will protect a lander from descent of at least four meters.
2. The conditions: You will build a landing device that will protect a raw egg from a fall of at least four meters. Your are free to use the equipment (below) in any way but there may be no platform for the lander to fall onto (landers don't have convenient foam landing pads to fall onto when they reach their destination).
3. The equipment: 1 egg, 60 cm of tape, 5 rubber bands, 1 small garbage or plastic bag, 10 paper clips, 1 m string, 20 plastic or paper straws, 1 plastic egg or similar sized object for testing. Your teacher may modify this equipment as they wish.
4. Building time will be determined by your teacher.
5. Before you begin, discuss with your group how you will construct the lander and in what ways you could cushion the egg at impact or slow its descent to reduce the shock of landing. You could research lander design online to gather ideas before you begin construction.

Lander design

7. Now that you have built and tested your egg lander you must evaluate its structure and performance.

(a) Describe the structure of your lander:

(b) On a scale of 1-5, how did your egg survive the fall? (1= completely scrambled, 5 = safe and sound):

(c) If your egg cracked, what could have been done to keep it from cracking if you repeated the test?

(d) Recall the landing devices designed used by other groups in your class. Which of these where the most effective? Can you explain why?

(e) Given enough material, it would be easily possible to design a lander than would protect the egg from a much higher fall than 5 m. The same applies to planetary landers. However, there are numerous constraints on the development of these devices, one of which is cost. Discuss with your group what other constraints there might be on the design on a lander for Mars:

Practical Investigations

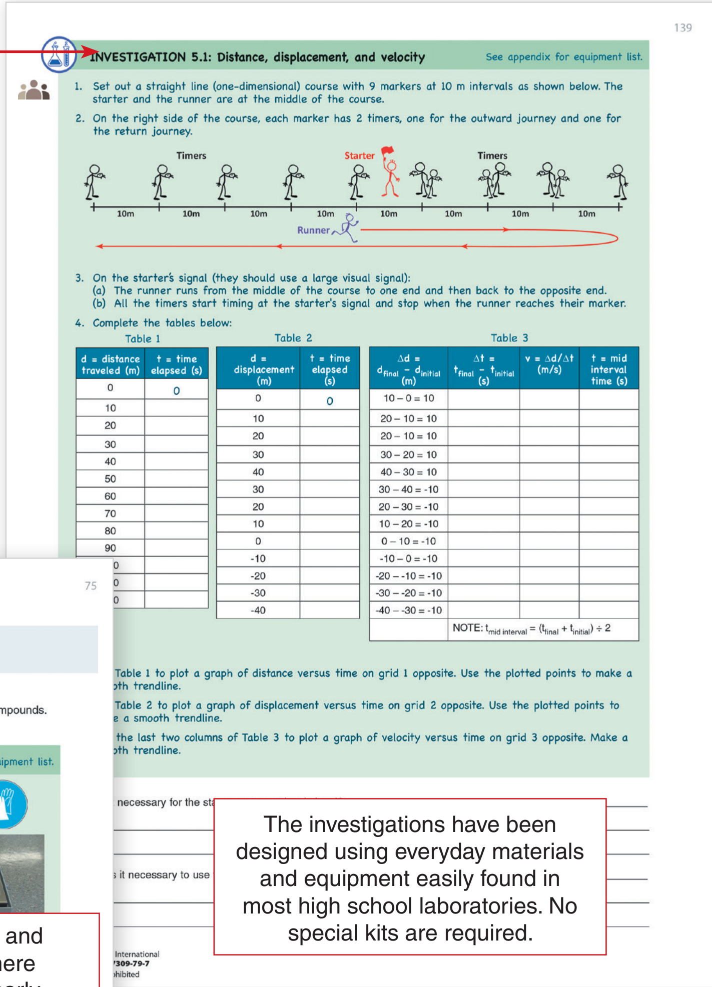
Throughout *Physical Sciences for NGSS*, students are given opportunities to explore phenomena through experimentation. These **investigative phenomena** are opportunities for students to develop competency in laboratory procedures, to practice and refine skills in observation and analysis, and to manipulate data. Some investigations act as stimulus material while others require students to take what they have already learned and apply their knowledge to a more complex scenario.

The investigations provide an excellent opportunity for collaborative work and will stimulate discussion and the sharing of ideas. You may wish to pair students of different abilities together. Confident students can guide and encourage less able students and, in this relaxed environment, striving students will be encouraged to share their own observations and thoughts. Collaboration through paired practical work provides an excellent opportunity for English language learners to interact in meaningful ways to extend their English language and scientific vocabulary.

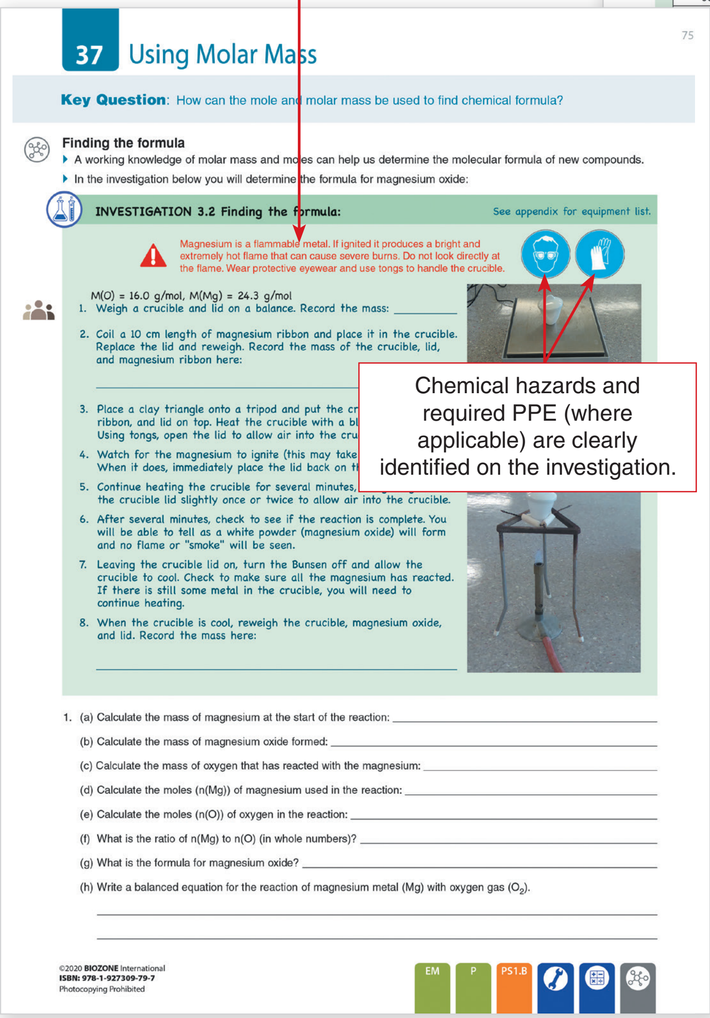
Each investigation is clearly numbered (sequentially through the chapter). A list of the equipment and chemicals required for each investigation is provided in the appendix. Only standard equipment is used (no special kits are required).

The investigations provide students with health and safety information at the start of the investigation.

- Ensure your students read through the procedure fully *before beginning* the investigation.
- Highlight any hazardous or important steps, and make sure the students follow your directions.
- Chapter 1 (Science Practices) contains basic safety guidelines for working in a laboratory. Students should complete these activities as appropriate before they begin their own investigations.



The investigations have been designed using everyday materials and equipment easily found in most high school laboratories. No special kits are required.



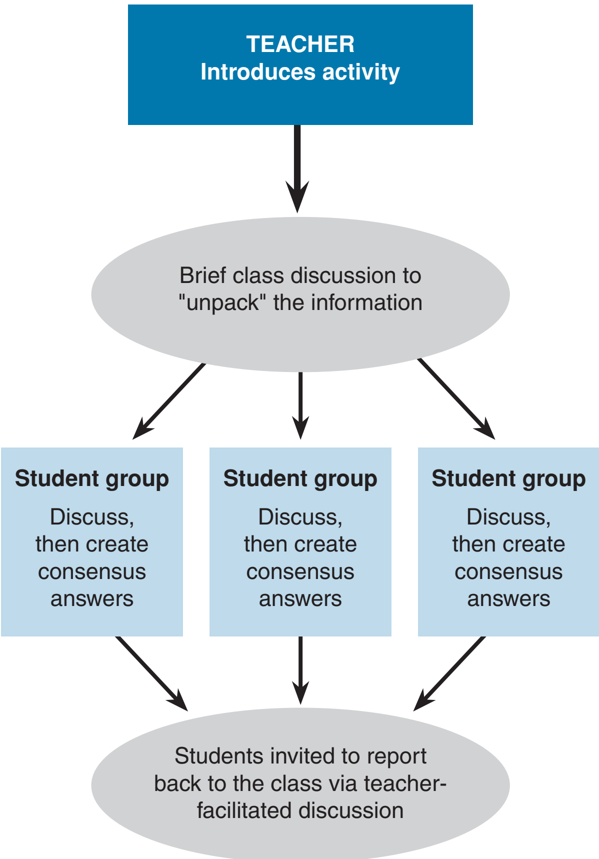
Chemical hazards and required PPE (where applicable) are clearly identified on the investigation.

Teaching Strategies for Classroom Use

Achieving effective differential instruction in classes is a teaching challenge. Students naturally have mixed abilities, varying backgrounds in the subject, and different language skills. Used effectively, BIOZONE's student books and supporting resources can make teaching a mixed ability class easier. Here, we suggest some approaches for differential instruction.

MAKING A START

Regardless of which activity you might be attempting in class, a short introduction to the task by the teacher is a useful orientation for all students. For collaborative work, the teacher can then divide the class into appropriate groups, each with a balance of able and less able students. Depending on the activity, the class may regroup at the end of the lesson for discussion.



Using collaboration to maximize learning outcomes

- The structure of *Physical Sciences for NGSS* allows for a flexible approach to unpacking the content with your students.
- The content can be delivered in a way to support collaboration, where students work in small groups to share ideas and information to answer and gain a better understanding of a topic, or design a solution to a problem.
- By working together to ask questions and evaluate each other's ideas, students maximize their own and each other's learning opportunities. They are exposed to ideas and perspectives they may not have come up with on their own.
- Collaboration, listening to others, and voicing their own ideas is valuable for supporting English language learners and developing their English and scientific vocabularies.
- Use a short, informal collaborative learning session to get students to exchange ideas about the answer to a question. Alternatively, collaboration may take a more formal role that lasts for a longer period of time (e.g. assign groups to work together for a practical activity, to research an extension question, or design a solution to a problem).

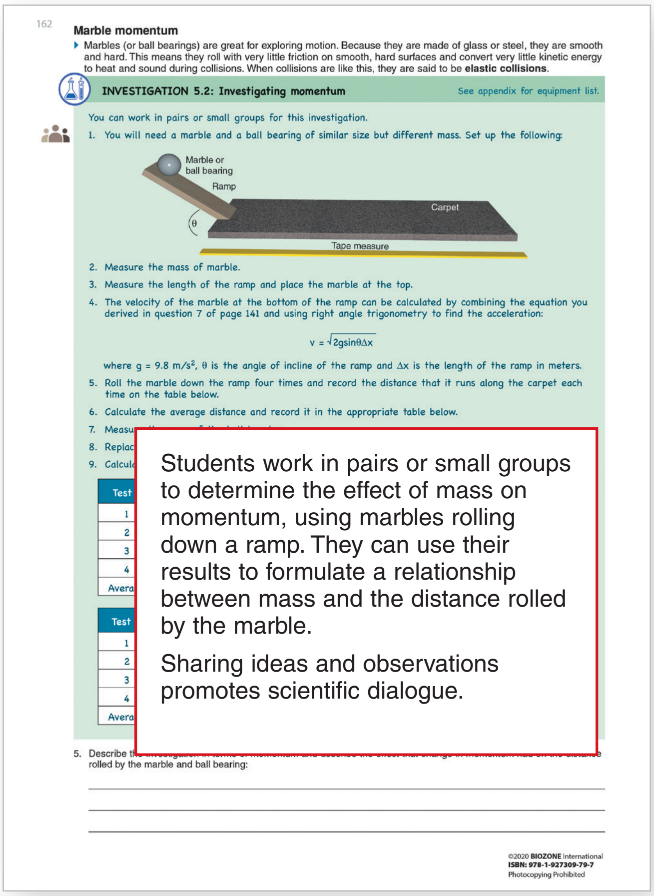
The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.

Students work in small groups so everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on discussing questions and formulating a consensus answer, not just sharing ideas.

At the end of the session, students report back on their findings. Each student should have enough knowledge to report back on the group's findings. Reporting consists primarily of providing answers to questions, but may involve presenting a report, model, or slide show, or contributing to a debate.

Peer to peer support

- **Peer-to-peer learning** is emphasized throughout the book, and is particularly valuable for more challenging activities in which the content is more complex or the questions require students to draw on several areas of their knowledge to solve a problem.
- Stronger students can assist their peers and both groups benefit from verbalizing their ideas. Students for whom English is a second language can ask their classmates to explain unfamiliar terms and this benefits the understanding of both parties.
- **Practical investigations** are an ideal vehicle for peer-to-peer learning. Students can work together to review their results, ask and answer questions, and describe phenomena. There are also opportunities for students to collaborate using online simulations (e.g. **Energy2D** shown below).



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Marble momentum

- Marbles (or ball bearings) are great for exploring motion. Because they are made of glass or steel, they are smooth and hard. This means they roll with very little friction on smooth, hard surfaces and convert very little kinetic energy to heat and sound during collisions. When collisions are like this, they are said to be **elastic collisions**.

INVESTIGATION 5.2: Investigating momentum See appendix for equipment list.

You can work in pairs or small groups for this investigation.

1. You will need a marble and a ball bearing of similar size but different mass. Set up the following:

2. Measure the mass of marble.
3. Measure the length of the ramp and place the marble at the top.
4. The velocity of the marble at the bottom of the ramp can be calculated by combining the equation you derived in question 7 of page 141 and using right angle trigonometry to find the acceleration:

$$v = \sqrt{2g\sin\theta\Delta x}$$

where $g = 9.8\ m/s^2$, θ is the angle of incline of the ramp and Δx is the length of the ramp in meters.

5. Roll the marble down the ramp four times and record the distance that it runs along the carpet each time on the table below.
6. Calculate the average distance and record it in the appropriate table below.

5. Describe th... rolled by the marble and ball bearing:

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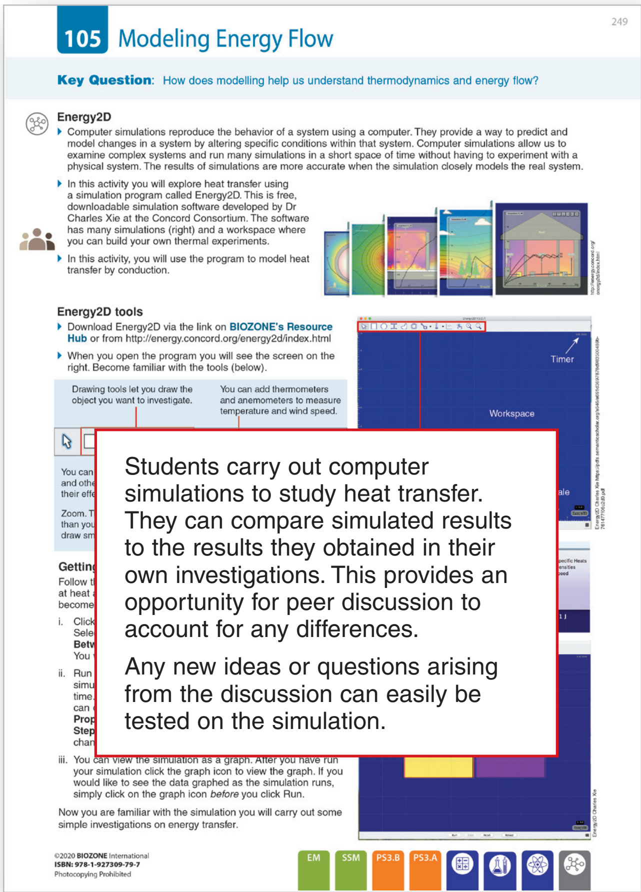
Students work in pairs or small groups to determine the effect of mass on momentum, using marbles rolling down a ramp. They can use their results to formulate a relationship between mass and the distance rolled by the marble.

Sharing ideas and observations promotes scientific dialogue.



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105 Modeling Energy Flow

Key Question: How does modelling help us understand thermodynamics and energy flow?

Energy2D

- Computer simulations reproduce the behavior of a system using a computer. They provide a way to predict and model changes in a system by altering specific conditions within that system. Computer simulations allow us to examine complex systems and run many simulations in a short space of time without having to experiment with a physical system. The results of simulations are more accurate when the simulation closely models the real system.
- In this activity you will explore heat transfer using a simulation program called Energy2D. This is free, downloadable simulation software developed by Dr Charles Xie at the Concord Consortium. The software has many simulations (right) and a workspace where you can build your own thermal experiments.
- In this activity, you will use the program to model heat transfer by conduction.

Energy2D tools

- Download Energy2D via the link on **BIOZONE's Resource Hub** or from http://energy.concord.org/energy2d/index.html
- When you open the program you will see the screen on the right. Become familiar with the tools (below).

iii. You can view the simulation as a graph. After you have run your simulation click the graph icon to view the graph. If you would like to see the data graphed as the simulation runs, simply click on the graph icon *before* you click Run.

Now you are familiar with the simulation you will carry out some simple investigations on energy transfer.

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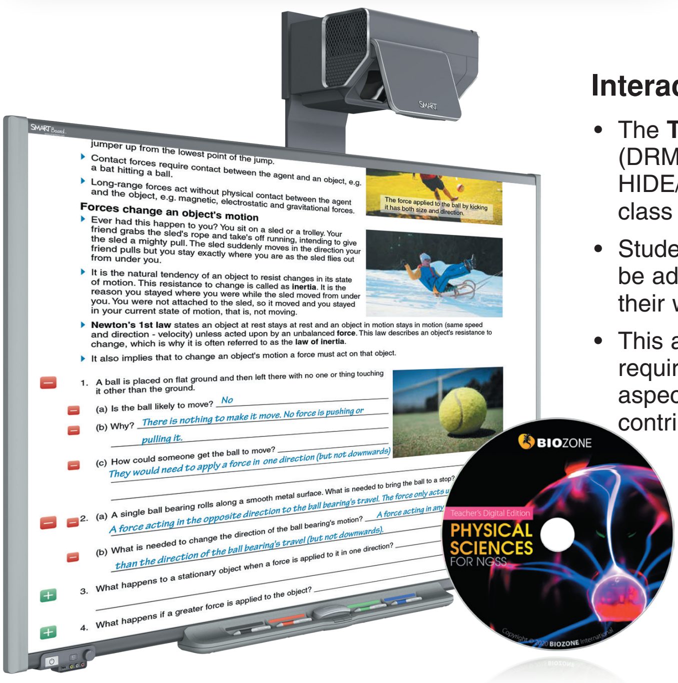
EM SSM PS3.B PS3.A

Students carry out computer simulations to study heat transfer. They can compare simulated results to the results they obtained in their own investigations. This provides an opportunity for peer discussion to account for any differences.

Any new ideas or questions arising from the discussion can easily be tested on the simulation.



Interactive revision of tasks in class

- The **Teacher's Digital Edition** provides a digital rights managed (DRM) version of the student book as PDF files. It features useful HIDE/SHOW answers, which can be used to review activities in class using a data projector or interactive whiteboard (left).
- Students benefit from the feedback in class, where questions can be addressed, and teachers benefit by having students self-mark their work and receive helpful feedback on their responses.
- This approach is particularly suited to activities with questions requiring a discussion, as students will be able to clarify some aspects of their responses. Stronger students can benefit by contributing to the explanatory feedback and class discussion.

NGSS as collaboration and discovery

- BIOZONE's *Physical Sciences for NGSS* provides multiple chances for collaboration and discovery. By working together and sharing ideas, students are exposed to different perspectives and levels of knowledge about phenomena.
- NGSS requires deeper student engagement with less emphasis on facts and more on understanding. By exploring principles and concepts within a context students are more easily able to apply these principles to new phenomena.
- BIOZONE's *Physical Sciences for NGSS* uses the NGSS framework to develop student understanding by providing a range of activities. These include getting students to think about and share what they already know and then build on this knowledge by exploring and explaining phenomena.

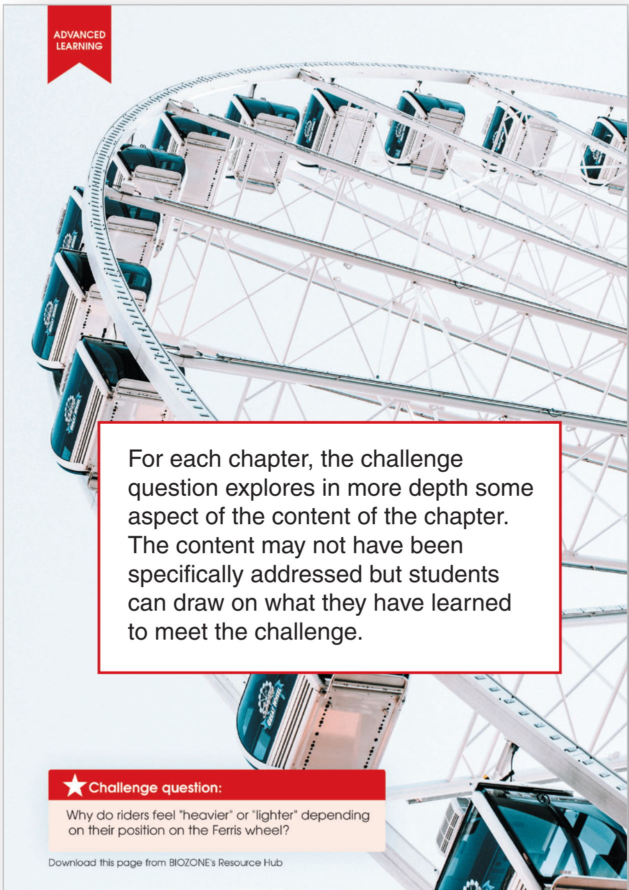
Student A is capable. He helps to lead the discussion and records the discussion in a structured way.

Students B and C are also capable but less willing to lead discussion they will add ideas to the discussion but need a little direction from A to do so.

Student D is less able but gains ideas and understanding from the discussion of students A, B, and C. She may add to the discussion as she gains confidence in the material being studied.

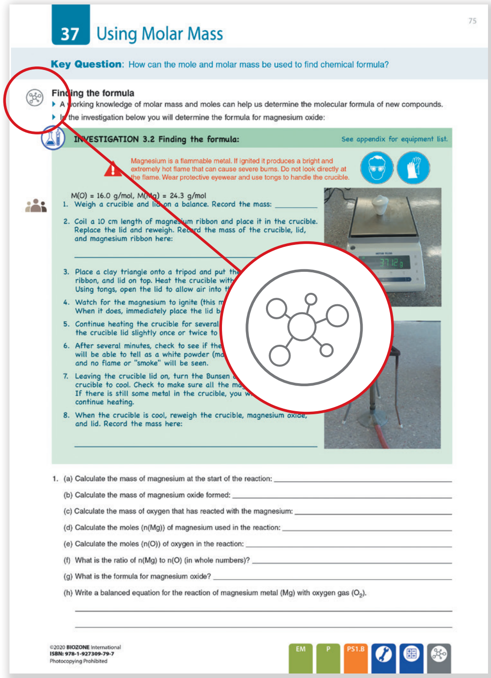
Student challenges

Do you ever need that little extra fun challenge for your more able students? The **Teacher's Edition** includes an extra page immediately preceding or following the **Teacher's Notes** at the beginning of each chapter (placement depends on pagination constraints). This page provides a challenge question for gifted and talented students in particular (or any students keen to have go!). It can be downloaded from **BIOZONE's Resource Hub**, where it is the first link for each chapter.

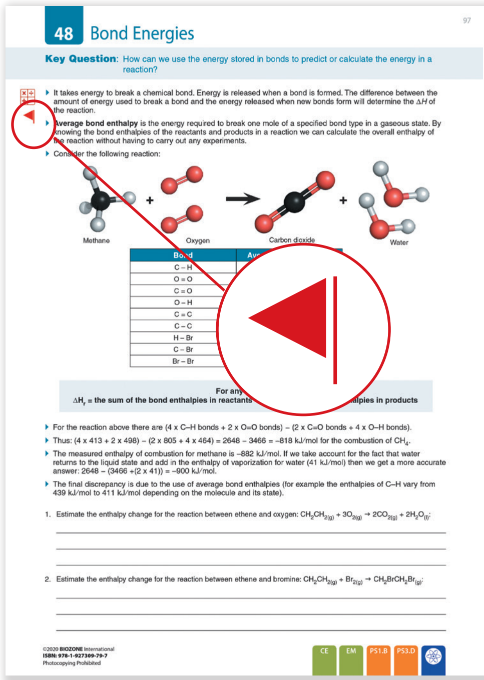


Differentiated Learning

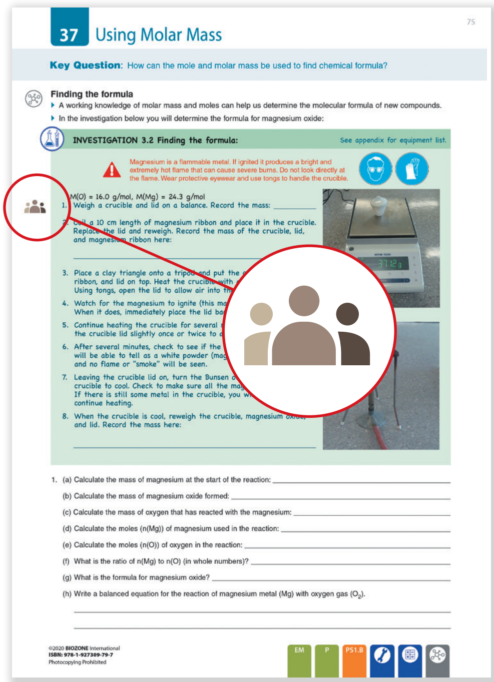
The structure of *Physical Sciences for NGSS* promotes differentiated instruction, and has been designed to cater for students of all abilities. BIOZONE's collaborative approach to science inquiry encourages students of all abilities to share their ideas and knowledge with their peers while at the same time broadening their own understanding of phenomena.
There are several ways you can use *Physical Sciences for NGSS* to implement differential instruction in your classroom:



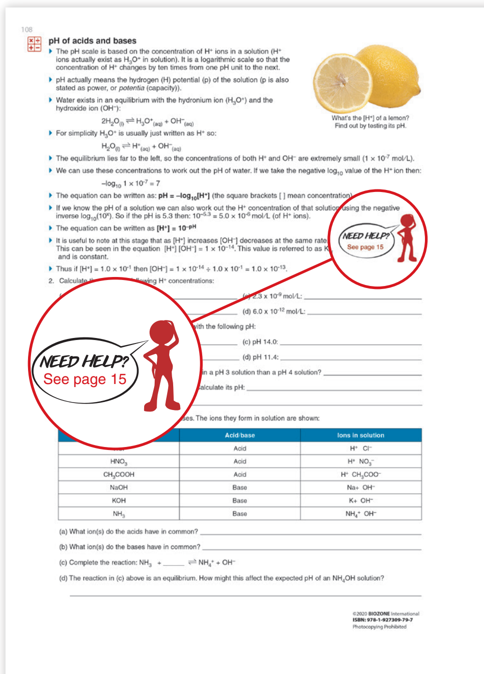
Animations and videos: Use the videos and animations on BIOZONE's Resource Hub to help striving learners with their English language skills and understanding of content. The Resource Hub also provides material tagged for gifted and talented students (also see p. CG11).



Red flag codes beside a section or question (on the Teacher's Edition or Teacher's Digital Edition) indicate that students may need extra guidance from the teacher. These questions are also suitable as challenges for more able students to tackle on their own. For able students, also see our **challenge question** pages (see p. CG11)



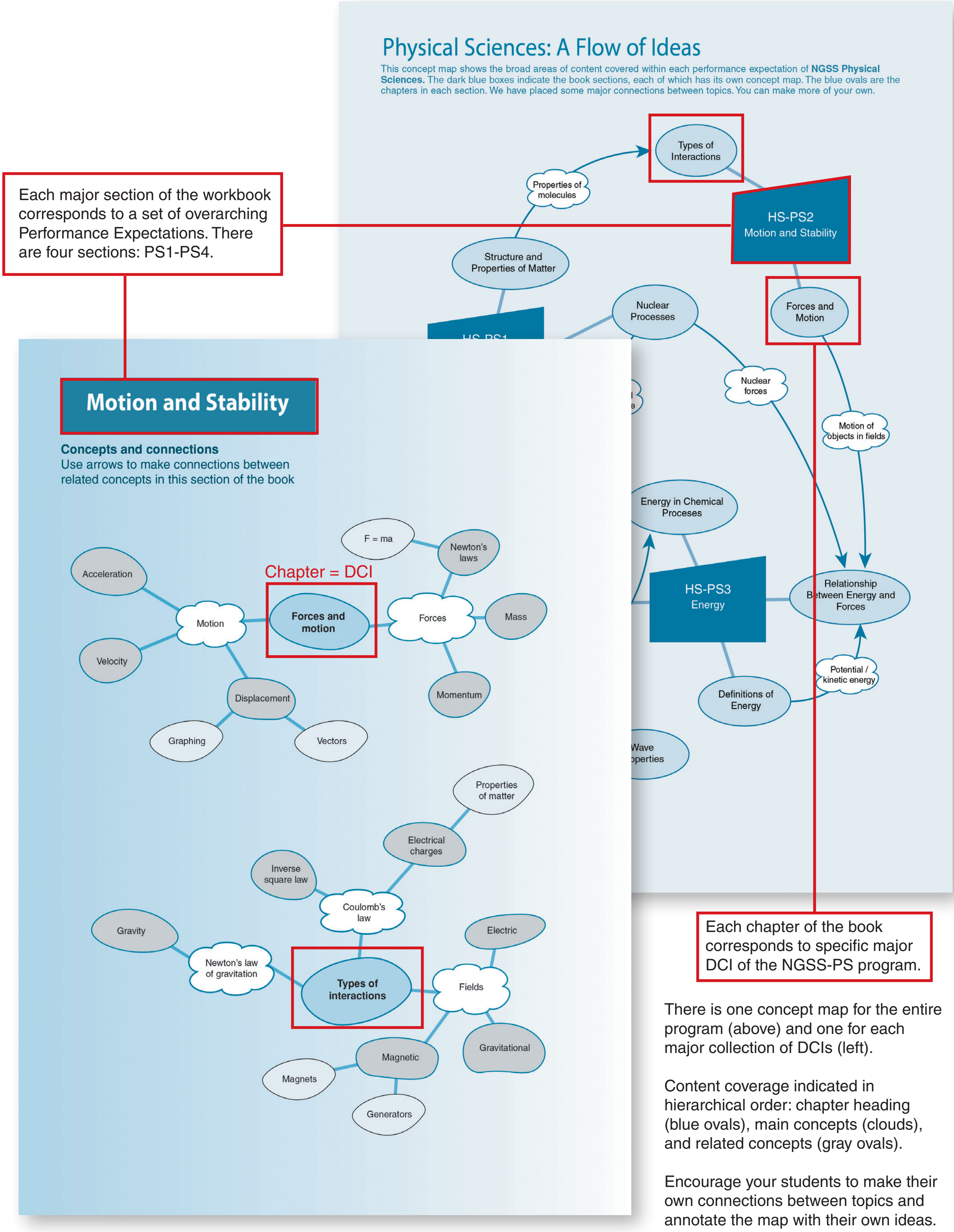
A group symbol indicates where students can work together. Group work provides opportunities for student collaboration and peer-to-peer support to explore phenomena. Working in groups, students can experiences the benefits of collaboration in the scientific process of discovery. By speaking and listening to each other, English language skills and scientific vocabulary are extended.



A red figure with a NEED HELP? icon helps students identify where they can go to get help with a specific skill. Skills and tips for computation, data analysis, plotting, statistical analysis, and aspects of experimental design are provided in the Basic Skills chapter at the start of the book. Students can visit this chapter regularly, or you can assign activities as homework before they attempt a specific task in class.

The Concept Maps

The concept maps in Physical Sciences for NGSS have two broad purposes: to provide a map of ideas covered in the program and to provide a vehicle for students to make their own connections between those ideas. They are particular useful as graphic organizers for striving students and visual learners. The introductory map provides an overview of the structure of the *NGSS Physical Sciences* program. Section concept maps divide the book into four parts, each providing a visual summary of one of four broad areas within the program, corresponding to PS1-PS4. Students can make their own connections between ideas on the concept maps as they work through the topics.



There is one concept map for the entire program (above) and one for each major collection of DCIs (left).

Content coverage indicated in hierarchical order: chapter heading (blue ovals), main concepts (clouds), and related concepts (gray ovals).

Encourage your students to make their own connections between topics and annotate the map with their own ideas.

Engineering Design Solutions

ETS SEPs, DCIs, and PEs as indicated in the NGSS framework are met through appropriately integrated engineering and design challenges. Typically tasks include analyzing problems, developing solutions using engineering, evaluating a design solution based on costs and benefits, or modeling a design solution.

The three dimensions of the NGSS framework appropriate to each design challenge are indicated in the chapter introduction of the Teacher's Edition (and Teacher's Digital Edition) and indicated through the tab system on the activity itself. Such tasks are usually examples of 'ELABORATE' as they involve the students applying what they have learned to solve a problem. As such, they also make good tasks for formative or summative assessment.

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INVESTIGATION 5.4: Building a lander — See appendix for equipment list.

1. You will now have the opportunity to put your knowledge of forces and momentum to the test. The objective of this investigation is to build a device that will protect a lander from descent of at least four meters.
2. The conditions: You will build a landing device that will protect a raw egg from a fall of at least four meters. Your are free to use the equipment (below) in any way but there may be no platform for the lander to fall onto (landers don't have convenient foam landing pads to fall onto when they reach their destination).
3. The equipment: 1 egg, 60 cm of tape, 5 rubber bands, 1 small garbage or plastic bag, 10 paper clips, 1 m string, 20 plastic or paper straws, 1 plastic egg or similar sized object for testing. Your teacher may modify this equipment as they wish.
4. Building time will be determined by your teacher.
5. Before you begin, discuss with your group how you will construct the lander and in what ways you could cushion the egg at impact or slow its descent to reduce the shock of landing. You could research lander design online to gather ideas before you begin construction.

Lander design

7. Now that you have built and tested your egg lander you must evaluate its structure and performance.

(a) Describe the structure of your lander: ______

(b) On a scale of 1-5, how did your egg survive the fall? (1= completely scrambled, 5 = safe and sound): ______

(c) If your egg cracked, what could have been done to keep it from cracking if you repeated the test?

(d) Recall the landing devices designed used by other groups in your class. Which of these
Can you explain why?

(e) Given enough material, it would be easily possible to design a lander than would protect
fall than 5 m. The same applies to planetary landers. However, there are numerous cons
these devices, one of which is cost. Discuss with your group what other constraints there
a lander for Mars:

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In this ETS example, students are asked to design and build a device to protect an egg from a fall of 4 meters using specified equipment. They test,evaluate, and refine their design to find a successful solution.

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1. On the **BioZone resource hub** watch the video in which an elaborate Rube Goldberg machine is used:

(a) How many times was energy transferred from one object or system to another? ______

(b) The energy in the original starting collision appears to run the whole device, with numerous reactions, often with greater energy. Explain why this isn't actually the case:

(c) Why can this machine be used only once? ______

Engineering energy conversion devices

- Unlike Rube Goldberg machines, most devices are designed to be as efficient as possible - to get the most work out of the input energy. As we learned, the energy in the universe is limited. And most of that energy is in forms inaccessible to us. What's more, when we harvest energy we lose much of it in the form of unusable heat energy. This further limits the energy available for our use. When we consider the energy demands for society and the energy we have available, efficiency becomes very important.
- You will now have the opportunity to design your own energy conversion device by applying the basic principles of energy conversion. This design challenge can be done outside the classroom in groups or individually as your teacher decides. Your teacher will determine the amount of time you can take.

The goal of this design challenge is simple: **you must build a device that will produce the greatest temperature change in 4 liters of water in fifteen minutes**. Water must be able to flow through or around you device based on the conditions below.

Your device will be attached to a heating station set up by your teacher so that the testing conditions will be uniform for all the devices. A basic heating station will consist of two heat lamps on chemistry lab stands with clamps which can be easily adjusted, a submersible fountain pump with adjustable flow control, a container that will hold the 4 liters of water that will be heated and is able to submerge the fountain pump, a thermometer, and a stopwatch or timer. The actual layout of the heating station will depend on your teacher and available materials.

Make sure to note that your device will need to connect to the water pump - you will need appropriate hose connections to attach your device to the pump hoses.

You will need to:
– research and submit a design to your teacher
– build and test the design
– refine the design and make any changes necessary
– submit a plan showing any revisions of the design to your teacher
– present a report that describes how your device works, its power output and efficiency, and situations where it will be best used.
– provide a demonstration of the device so that it can be compared to other devices designed by your classmates.

Available materials may be limiting. Be sure you are aware of the materials you have available when designing your device. Keep note of any portion of your device where an unavailable material may have made a difference.

Note: **Efficiency = energy in / energy out**.

Energy out can be calculated from the temperature change in the water. 1 mL (1 g) of water requires 4.2 joules to raise its temperature by 1°C or $E = m \times 4.2 \times \Delta T$ (where m = mass in grams of water and ΔT = the change in temperature).

Energy in can be calculated using the power ratings of the heat lamps. Heat lamps are approximately 96% efficient, so the energy in will be the wattage of the heat lamps × 0.96 × time in seconds.

2. (a) In the space below, summarize your research notes on a possible device to build. You may use extra paper if needed:

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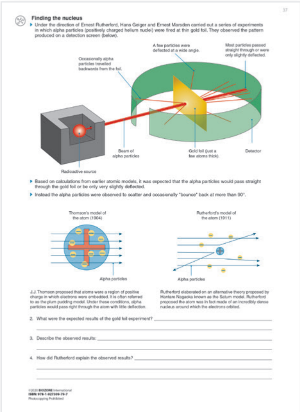
Students have previously studied energy transfer. They use their knowledge to design a way to heat a flow of water given various constraints. In designing their solution, students must take into consideration the materials used and the efficiency of their design in achieving the outcome.

The Nature of Science

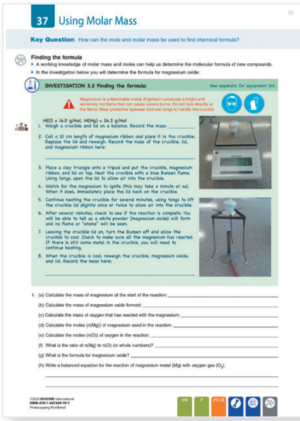
The Nature of Science combines established information with new knowledge to constantly refine what we know about the natural world. Eight Nature of Science understandings are presented in the NGSS document. Four are associated most closely with Science and Engineering Practices, and four with the Crosscutting Concepts. The Nature of Science understandings have been incorporated into most activities in *Physical Sciences for NGSS*, so we have not identified them specifically on the activity pages. Some examples of activities relating to the eight Nature of Science understandings are illustrated below. The subheading to which they relate is also given.

Nature of science understandings most closely associated with science and engineering practices



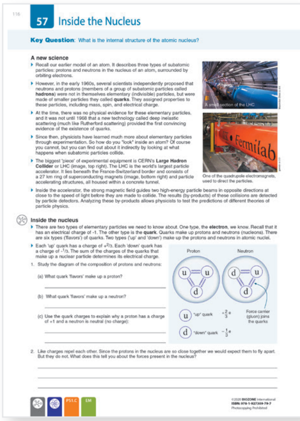
Scientific investigations use a variety of methods.

- Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge



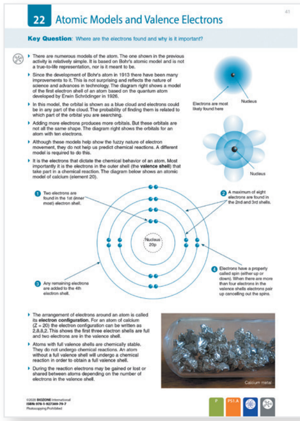
Scientific knowledge is based on empirical evidence.

- Scientific knowledge is based on empirical evidence.



Scientific knowledge is open to revision in light of new evidence.

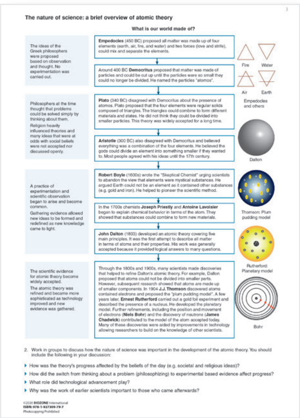
- Most scientific knowledge is quite durable but is subject to change based on new evidence and/or reinterpretations of existing evidence.



Science models, laws, mechanisms, and theories explain natural phenomena.

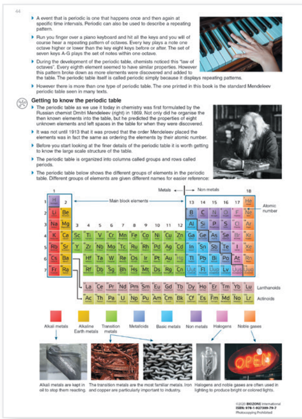
- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

Nature of science understandings most closely associated with crosscutting concepts



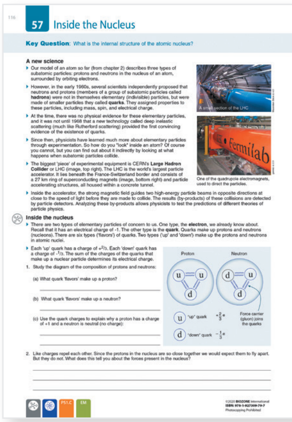
Science is a way of knowing.

- Scientific knowledge has a history that includes refinement of, and changes to, theories, ideas, and beliefs over time.



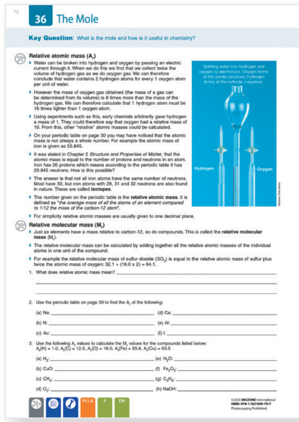
Scientific knowledge assumes an order and consistency in natural systems.

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future.



Science is a human endeavor.

- Technological advances have influenced the progress of science and science has influenced advances in technology.



Science addresses questions about the natural and material world.

- Scientific knowledge indicates what can happen in natural systems - not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.

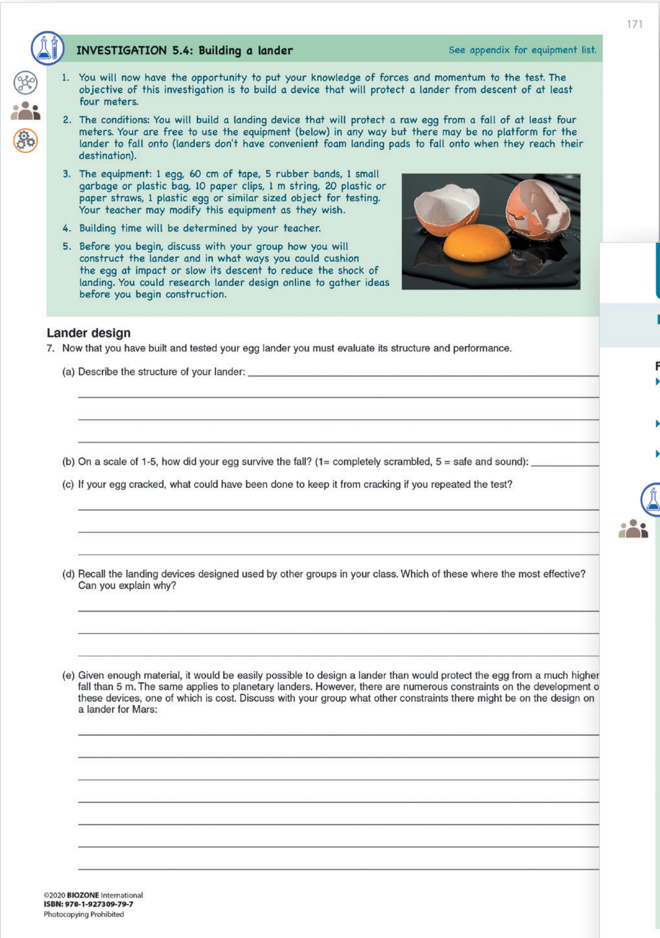
Evaluating Student Performance

Physical Sciences for NGSS provides ample opportunity for students to demonstrate their understanding and proficiency in all three dimensions of the standards. Opportunities for both formative and summative and assessment are provided.

All activities (including assessments) have been designed to be three-dimensional in their approach, with the goal to enabling achievement of specific performance expectations. Performance expectations (PE) are not always met through completion of one activity or assessment, but through completion of a connected suite of tasks (as intended by the framework).

Assessments involve a variety of tasks as appropriate to a 3D approach, e.g., constructing models, analyzing and interpreting data, explaining, and communicating understanding through short and long answers, drawings, calculations, group work, design, and problem solving. The structure of the tasks is such that students use specific science and engineering practices and apply relevant crosscutting concepts to demonstrate their understanding of disciplinary core ideas.

Formative assessments can be chosen by the teacher to determine how a student's knowledge is progressing within a selected topic. We suggest that ‘ELABORATE’ and ‘EVALUATE’ sections of activities be used for formative assessment. These may incorporate some aspect of a performance expectation with the goal being to build confidence. Teachers can revise their instruction, revisit material, or set further tasks if a student is having difficulty with the material. Revisiting the Anchoring Phenomenon near the end of each instructional segment also provides a way to evaluate student understanding.



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(b) On a scale of 1-5, how did your egg survive the fall? (1= completely scrambled, 5 = safe and sound): ______

(c) If your egg cracked, what could have been done to keep it from cracking if you repeated the test?

(d) Recall the landing devices designed used by other groups in your class. Which of these where the most effective? Can you explain why?

(e) Given enough material, it would be easily possible to design a lander than would protect the egg from a much higher fall than 5 m. The same applies to planetary landers. However, there are numerous constraints on the development o these devices, one of which is cost. Discuss with your group what other constraints there might be on the design on a lander for Mars:

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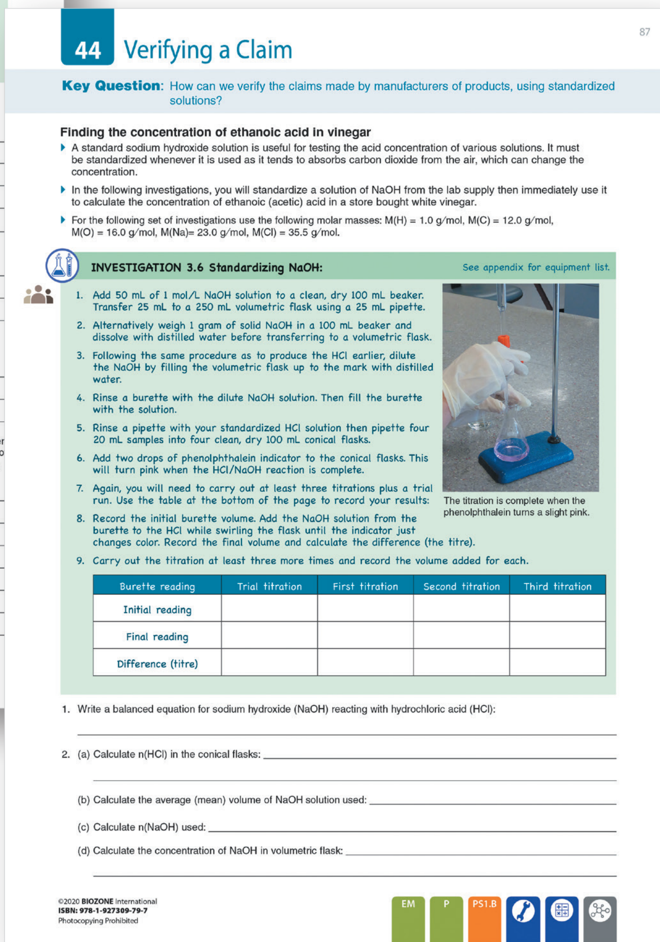

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44 Verifying a Claim

Key Question: How can we verify the claims made by manufacturers of products, using standardized solutions?

Finding the concentration of ethanoic acid in vinegar

- A standard sodium hydroxide solution is useful for testing the acid concentration of various solutions. It must be standardized whenever it is used as it tends to absorbs carbon dioxide from the air, which can change the concentration.
- In the following investigations, you will standardize a solution of NaOH from the lab supply then immediately use it to calculate the concentration of ethanoic (acetic) acid in a store bought white vinegar.
- For the following set of investigations use the following molar masses: M(H) = 1.0 g/mol, M(C) = 12.0 g/mol, M(O) = 16.0 g/mol, M(Na)= 23.0 g/mol, M(Cl) = 35.5 g/mol.

INVESTIGATION 3.6 Standardizing NaOH: See appendix for equipment list.

1. Add 50 mL of 1 mol/L NaOH solution to a clean, dry 100 mL beaker. Transfer 25 mL to a 250 mL volumetric flask using a 25 mL pipette.
2. Alternatively weigh 1 gram of solid NaOH in a 100 mL beaker and dissolve with distilled water before transferring to a volumetric flask.
3. Following the same procedure as to produce the HCl earlier, dilute the NaOH by filling the volumetric flask up to the mark with distilled water.
4. Rinse a burette with the dilute NaOH solution. Then fill the burette with the solution.
5. Rinse a pipette with your standardized HCl solution then pipette four 20 mL samples into four clean, dry 100 mL conical flasks.
6. Add two drops of phenolphthalein indicator to the conical flasks. This will turn pink when the HCl/NaOH reaction is complete.
7. Again, you will need to carry out at least three titrations plus a trial run. Use the table at the bottom of the page to record your results:
8. Record the initial burette volume. Add the NaOH solution from the burette to the HCl while swirling the flask until the indicator just changes color. Record the final volume and calculate the difference (the titre).
9. Carry out the titration at least three more times and record the volume added for each.

The titration is complete when the phenolphthalein turns a slight pink.

Burette reading	Trial titration	First titration	Second titration	Third titration
Initial reading				
Final reading				
Difference (titre)				

1. Write a balanced equation for sodium hydroxide (NaOH) reacting with hydrochloric acid (HCl):

2. (a) Calculate n(HCl) in the conical flasks: ______

(b) Calculate the average (mean) volume of NaOH solution used: ______

(c) Calculate n(NaOH) used: ______

(d) Calculate the concentration of NaOH in volumetric flask: ______

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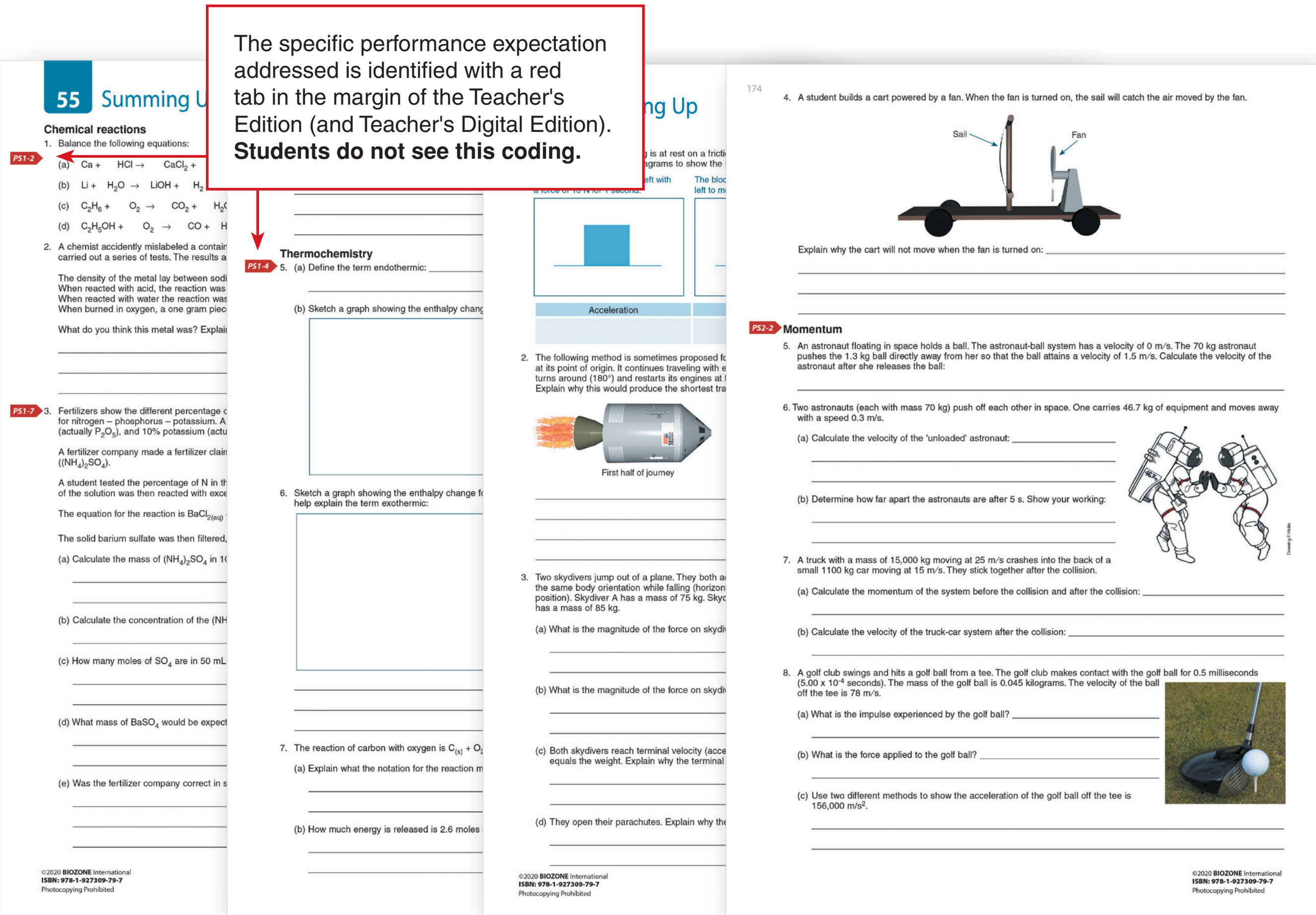
EM P PS1.B

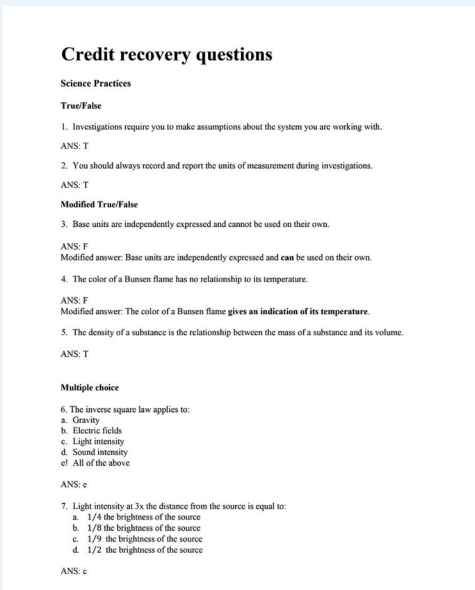
Summing up tasks at the close of each instructional segment can be used as a formal summative testing moment to evaluate student skills, understanding, and application of knowledge. These tasks are designed to meet part or all of one or more performance expectations. Material to address specific performance expectations is identified with a red tab in the margin throughout the Teacher's Edition. Performance expectations are also identified in the chapter introduction for the instructional segment, and in the tables summarizing BIOZONE's 3D approach by chapter earlier in this guide.
Note: All coding associated with assessment is hidden from the student and is available only in teacher's materials.



Summative assessments are three dimensional assessments of student understanding, including but not restricted to:
• Short answer questions • Long answer questions • Graphing • Data analysis and interpretation • Modeling

Does BIOZONE provide test banks?

- We are currently developing test banks to test the DCI content within each instructional segment.
- These will test content knowledge, and take the form of:
  - Multiple choice
  - True/False
  - Modified True/False
  - Multiple response
  - Matching
  - Short answer
  - Yes/No
  - Numeric response
- Test bank questions will be formatted for ingestion into test generator software such as ExamView.
- Standard and credit recovery options will be available.



Credit recovery questions

Science Practices

True/False

1. Investigations require you to make assumptions about the system you are working with.

ANS: T

2. You should always record and report the units of measurement during investigations.

ANS: T

Modified True/False

3. Base units are independently expressed and cannot be used on their own.

ANS: F
Modified answer: Base units are independently expressed and **can** be used on their own.

4. The color of a Bunsen flame has no relationship to its temperature.

ANS: F
Modified answer: The color of a Bunsen flame **gives an indication of its temperature**.

5. The density of a substance is the relationship between the mass of a substance and its volume.

ANS: T

Multiple choice

6. The inverse square law applies to:
a. Gravity
b. Electric fields
c. Light intensity
d. Sound intensity
e. All of the above

ANS: e

7. Light intensity at 3x the distance from the source is equal to:
a. 1/4 the brightness of the source
b. 1/8 the brightness of the source
c. 1/9 the brightness of the source
d. 1/2 the brightness of the source

ANS: c

Identifying CCCs and SEPs by Number

CROSSCUTTING CONCEPTS (CCCs)

CCCs are unifying ideas that apply across all disciplines of science. A CCC connects topics where the same unifying concept underpins the content. A statement for each numbered CCC is provided below. CCCs are identified by number in the tables following and in the embedded coding in the chapter introductions (Teacher's Edition). Statements are paraphrased.

1: Patterns
In grades 9-12, students observe patterns in systems at different scales and cite patterns as evidence for causality in supporting explanations of phenomena. They recognize that classifications or explanations at one scale may need revision using a different scale, thus requiring improved investigations and experiments. They identify and analyze patterns, and use analysis to re engineer and improve designed systems.

2: Cause and effect
In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlations and to make claims about cause and effect. They suggest cause and effect relationships to explain and predict behaviors in natural and designed systems. They also propose causal relationships by examining what is known about smaller-scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

3: Systems and system models
In grades 9-12, students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models to simulate the flow of energy, matter, and interactions within and between systems at different scales. They also use models and simulations to predict the behavior of a system and recognize why these predictions have limited precision and reliability. They also design systems to do specific tasks.

4: Structure and function
In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal a system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their structure, the way their components are shaped and used, and the molecular substructures of their various materials.

5: Scale, proportion, and quantity
In grades 9-12, students understand that the significance of a phenomenon depends on the scale, proportion, and quantity at which it occurs. They recognize that patterns observable at one scale many not be observable or exist at other scales and that some systems can only be studied indirectly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another.

6: Energy and matter
In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed, only transferred and transformed. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

7: Stability and change
In grades 9-12, students understand that much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over short or very periods of time. They see that some changes are irreversible and that negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize that systems can be designed for more or less stability.

SCIENCE & ENGINEERING PRACTICES (SEPs)

SEPs for NGSS are overlapping and interconnected practices that students should know and understand. A statement for each numbered SEP is provided below. SEPs are identified by number in the tables following and in the embedded coding in the chapter introductions (Teacher's Edition).

1: Asking questions and defining problems
"Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations."

2: Developing and using models
"Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s)."

3: Planning and carrying out investigations
"Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual mathematical, physical, and empirical models".

4: Analzying and interpreting data
"Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data."

5: Using mathematics and computational thinking
"Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simulations are created and used based on mathematical models of basic assumptions."

6: Constructing explanations and designing solutions
"Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories".

7: Engaging in argument from evidence
"Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science."

8: Obtaining, evaluating, and communicating information
"Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs."

Summary of BIOZONE's 3D Approach By Chapter

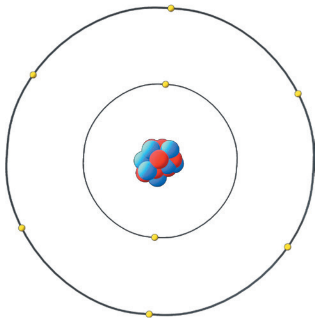
Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), Disciplinary Core Ideas (DCIs), and Performance Expectations (PEs) for each chapter of *Physical Sciences for NGSS* are listed in the tables following. An introductory "Science Practices" chapter is also included. Performance Expectations are met within the chapter and/or the *Summing Up* activity.

1: SCIENCE PRACTICES

Activity	SEP	DCI	CCC	PE
1	1, 6, 7, 8	NA	4	NA
2	2	NA	4	NA
3	1	NA		NA
4	3,5	NA		NA
5	5,8	NA		NA
6	3, 4, 5	NA		NA
7	4, 5	NA		NA
8	3,4,5,8	NA	1, 2	NA
9	3,4,5	NA	1	NA
10	3	NA		NA
11	5	NA		NA
12	3	NA		NA
13	2, 3, 6	NA		NA
14	3	NA		NA
15	2, 3, 6	NA		NA
16		NA	3	NA

2: STRUCTURE AND PROPERTIES OF MATTER

Activity	SEP	DCI	CCC	PE
18-21	2	PS1.A	1	
22	2	PS1.A	1	HS-PS1-1
23	2, 4	PS1.A	1	
24-25	2	PS1.A	1	HS-PS1-1
26-28	2	PS1.A	1	
29, 30	3, 6	PS1.A	1	
31	2, 3	PS1.A	1	HS-PS1-3
33	2	PS1.A		HS-PS1-1



3: CHEMICAL REACTIONS

Activity	SEP	DCI	CCC	PE
35-36	5, 6	PS1.B	5	HS-PS1-7
37	3, 5, 6	PS1.B	1, 5	HS-PS1-7
38-40	5, 6	PS1.B	1, 5	HS-PS1-7
41	5, 6	PS1.B	1, 3, 5	HS-PS1-2, HS-PS1-7
42	5, 6	PS1.B	1, 5	HS-PS1-2, HS-PS1-7
43	2, 3, 5, 6	PS1.B	1, 5	HS-PS1-2, HS-PS1-7
44	3, 5, 6	PS1.B	1, 5	HS-PS1-2, HS-PS1-7
45	3, 6	PS1.B	1	HS-PS1-5
46	2, 3	PS1.B, PS3.D	5	HS-PS1-4
47	2, 3, 5	PS1.B, PS3.D	5	HS-PS1-4
48	2	PS1.B, PS3.D	5	HS-PS1-4
49	3, 6	PS1.B	4, 7	HS-PS1-5
50-51	6	PS1.B	4, 7	HS-PS1-5
52	6	PS1.B	7	HS-PS1-6
53	3, 5, 6	PS1.B	7	
55	2, 5, 6	PS1.A, PS1.B	1, 5	HS-PS1-2, HS-PS1-4, HS-PS1-5, HS-PS1-6 HS-PS1-7

4: NUCLEAR PROCESSES

Activity	SEP	DCI	CCC	PE
57	2, 3	PS1.C	5	HS-PS1-8
58	2	PS1.C	5	HS-PS1-8
59	2, 3, 8	PS1.C	5	HS-PS1-8
60	2	PS1.C	5, 7	HS-PS1-8
61	2	PS1.C	5, 7	
63	2	PS1.C	5	HS-PS1-8

5: FORCES AND MOTION

Activity	SEP	DCI	CCC	PE
65-66	3, 4	PS2.A	2	
67-68	4	PS2.A	2	HS-PS2-1
69-70	2, 5, 4	PS2.A	2	
71	3, 5	PS2.A	4	
72-73	5	PS2.A	4	HS-PS2-2
74	3, 5	PS2.A	4	HS-PS2-2
75	3, 5, 6	PS2.A, ETS1.A, ETS1.C	2	HS-PS2-2, HS-PS2-3, HS-EST-1-2, HS-EST1-3
77	4, 5	PS2.A	2, 4	HS-PS2-1, HS-PS2-2

6: TYPES OF INTERACTIONS

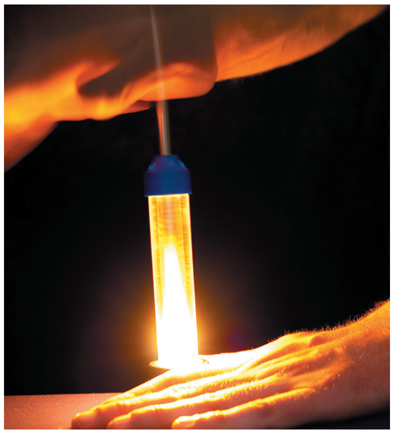
Activity	SEP	DCI	CCC	PE
79	5	PS2.B	1	
80	2, 5, 6	PS2.B	1	HS-PS2-4
81	3, 5	PS2.B	1	
82	2, 5	PS2.B	1, 4	HS-PS2-4
83	2	PS3.C	2	HS-PS3-5
84	2, 3	PS2.B, PS3.C	1, 2	
85	2, 3	PS2.B, PS3.C	2	
86	3	PS2.B	2	HS-PS3-5
87	2	PS3.C	2	HS-PS3-5
88	3, 6	PS2.B, PS3.A	2, 5	HS-PS2-5, HS-PS3-5
89	3, 6, 8	PS2.B	6	HS-PS2-6
91	2, 5, 8	PS2.B, PS3.C	1, 2, 6	HS-PS2-4, HS-PS2-6, HS-PS3-5

7: DEFINITIONS OF ENERGY

Activity	SEP	DCI	CCC	PE
93	2, 6	PS3.A	4, 5	
94	2, 5	PS3.A	4, 5	
95	2, 5	PS3.A	4, 5	HS-PS3-1
96	2, 5	PS3.A	4, 5	HS-PS3-2
97	2, 3, 5	PS3.A	4, 5	HS-PS3-2
98	2, 5	PS3.A	2, 4, 5	HS-PS3-2
99	2, 5	PS3.A	4, 5	
101	2	PS3.A	4	HS-PS3-1

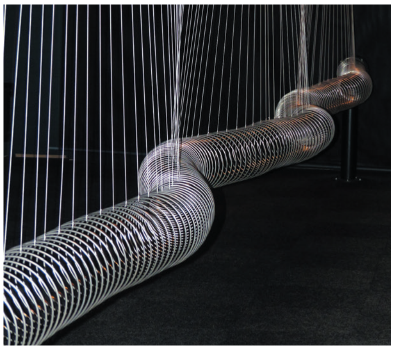
8: CONSERVATION OF ENERGY AND ENERGY TRANSFER

Activity	SEP	DCI	CCC	PE
103	2, 5, 6	PS3.B, PS3.D	4, 5	HS-PS3-1, HS-PS3-2 HS-PS3-3, HS-PS3-4
104	3, 6	PS3.B, PS3.D	4, 5	HS-PS3-1, HS-PS3-3, HS-PS3-4
105	2, 3, 5	PS3.A, PS3.B	4, 5	HS-PS3-1
106	3, 5	PS3.B	4	
107	5	PS3.B	4	
108	2, 3, 6	PS3.B, PS3.D, ETS1.1	4, 5	HS-PS3-1, HS-PS3-3, HS-PS3-4, HS-ETS1-1
110	2	PS3.A, PS3.B	4, 5	HS-PS3-1, HS-PS3-2



9: WAVE PROPERTIES

Activity	SEP	DCI	CCC	PE
112-113	3, 5	PS4.A	2	HS-PS4-1
114	5	PS4.A	2	HS-PS4-1
115	5	PS4.A	2	
116	3, 5	PS4.A	2	HS-PS4-1
117	3, 7	PS4.A	2, 4	
118	1, 4, 8	PS4.A	2, 7	HS-PS4-2, HS-PS4-5
120	5	PS4.A	2	HS-PS4-1



10: ELECTROMAGNETIC RADIATION

Activity	SEP	DCI	CCC	PE
122	7	PS4.B	4, 5	
123	3, 7	PS4.B	4, 5	HS-PS4-3
124	8	PS4.B	2	HS-PS4-4
125	8	PS4.B	2	HS-PS4-4
127		PS4		HS-PS4-3

11: INFORMATION TECHNOLOGY AND INSTRUMENTATION

Activity	SEP	DCI	CCC	PE
128	8	PS4.C	2	
129-130	8	PS4.C	2	
132	8	PS4.C	2	HS-PS4-5

Identifying CCSS Connections

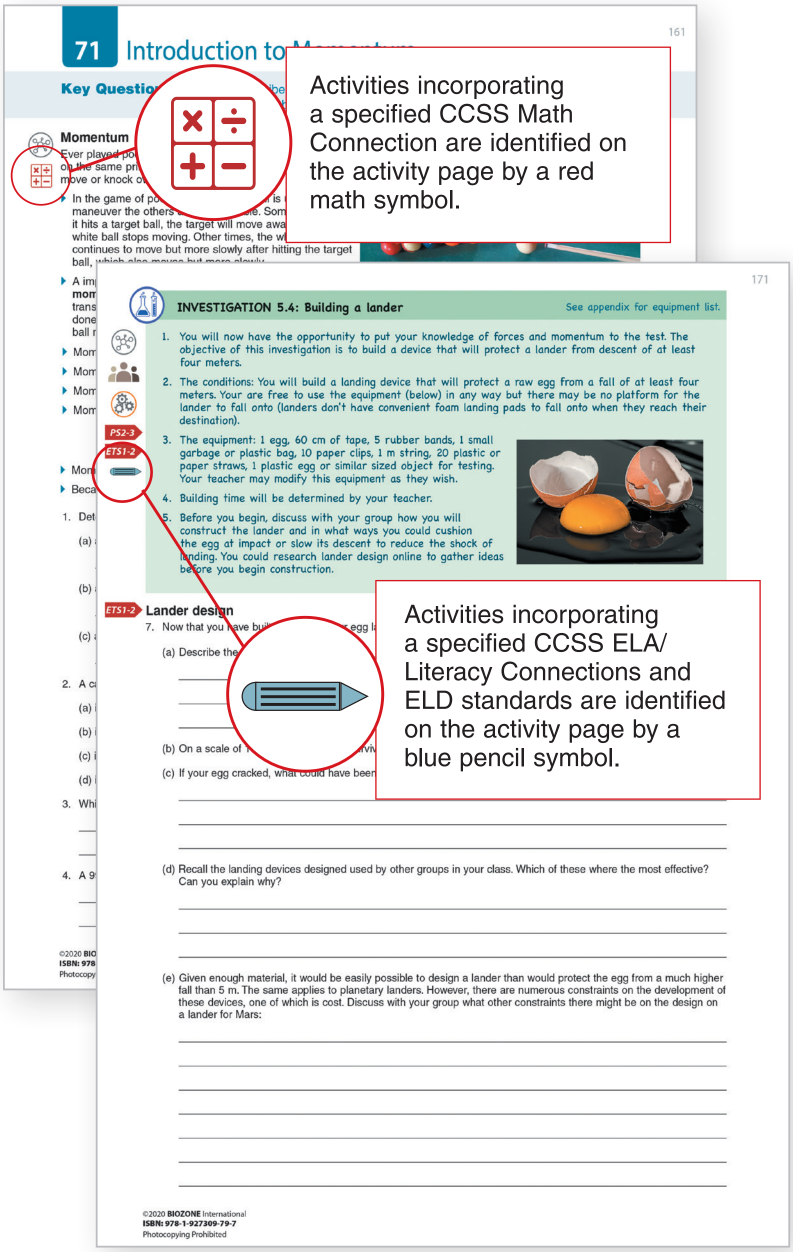
The activities in *Physical Sciences for NGSS* provide many opportunities to address the Common Core State Standards (CCSS) for numeracy, and literacy, and English language development (ELD). The incorporation of these standards allows students to practice and develop these key skills while exploring science.

Activities incorporating the CCSS Math Connections, ELA/ literacy, and ELD Connections specified in the NGSS Science Framework are identified by codes (right) in the **Teacher's Edition** and **Teacher's Digital Edition**.
Note that this coding is a tool for the teacher and is not present in the Student Edition.

- A red calculator indicates a math connection.
- A blue pencil indicates an ELA/literacy or ELD connection.

A list of the specific Math Connections, ELA/ Literacy Connections and ELD Standards addressed in the NGSS framework can be found in the tables at the bottom of this page and on the following pages.

BIOZONE recognizes that ELD Standards are not to be used in isolation, and are intended to be implemented in conjunction with ELA/Literacy and other academic content standards. This is why you will see them appearing along with the relevant ELA/literacy connection in the following tables.



1: SCIENCE PRACTICES

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
1	The Nature of Science		WHST.9-12.2, SL.9-12.1, ELD.P1.11-12.1, 5
6	Accuracy and Precision	MP.6, HSN-Q.A., HSS-ID.A.2	
7	Working With Numbers	MP.4, HSA-CED.A.4	
8	Graphical Analysis	MP.4, HSS-ID.A.1, HSS.ID.C.7	
9	Describing the Data	MP.4, HSS.ID.A.2, HSS.ID.A.2	
10	Investigations in Physics	MP.4, HSS-ID.A.1	
15	Measurement and Quantitative Analysis		SL.9-12.1, ELD.P1.11-12.1, 5

2: STRUCTURE AND PROPERTIES OF MATTER

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
20	Atomic Theory and Rutherford's Experiment		WHST.9-12.8
24	Trends in the Periodic Table	MP4	

3: CHEMICAL REACTIONS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
36	The Mole	MP.2, HSN-Q.A.1	
37	Using Molar Mass	MP.2, HSN-Q.A.2	
38	Empirical Formulae	MP.2, HSN-Q.A.2	
39	Percentage Composition	MP.2, HSN-Q.A.2	
40	Balancing Equations	MP.1, MP.2, HSN-Q.A.1	
41	Stoichiometry	MP.2, HSN-Q.A.1, HSN-Q.A.3	
43	Creating Standard Solutions	MP.2, HSN-Q.A.1 , HSN-Q.A.3	
44	Verifying a Claim	MP.2, HSN-Q.A.1 , HSN-Q.A.3	
47	Enthalpy and Chemical Reactions	MP.2, HSN-Q.A.1, HSN-Q.A.3	
48	Bond Energies	MP.4	
49	Reversible Reactions	MP.4, HSN-Q.A.1	
52	Industrial Equilibria	MP.4, HSN-Q.A.1	
53	Acids and Bases	MP.4, HSN-Q.A.1	
55	Summing Up	MP.4, HSN-Q.A.1	

4: NUCLEAR PROCESSES

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
59	Radioactive Decay	MP.4	
61	Fission vs Fusion	MP.4	

5: FORCES AND MOTION

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
65	Distance and Displacement	MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2	RST.11-12.7
66	Speed and Velocity	MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSA-SSE.A.1, HSA-CED.A.4, HSS-ID.A.1	
67	Acceleration	MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSA-SSE.A.1, HSA-CED.A.1, HSA-CED.A.2 HSA-CED.A.4, HSA-SSE.B.3	
69	Newton's Second Law	MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSA-SSE.A.1, HSA-CED.A.1, HSA-CED.A.2 HSA-CED.A.4	
71	Introduction to Momentum	MP.2, MP.4, HSN-Q.A.1	
72	Investigating Collisions	MP.2, MP.4,	
73	Law of Conservation of Momentum	MP.2, MP.4, HSA-CED.A.1	
74	Impulse	MP.2, MP.4, HSN-Q.A.1	
75	Crumple Zones and Crash Helmets	MP.2, MP.4, HSN-Q.A.1	
76	Review Your Understanding	MP.2, MP.4, HSN-Q.A.1	
77	Summing Up	MP.2, MP.4, HSN-Q.A.1	

6: TYPES OF INTERACTIONS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
79	Gravity	MP.4	
80	Newton's Law of Gravitation	MP.2, MP.4, HSN-Q.A.1, HSA-SSE.A.1, HSA-CED.A.1, HSA-CED.A.2 HSA-CED.A.4, HSA-SSE.B.3	
82	Coulomb's Law	MP.2, MP.4, HSN-Q.A.1, HSA-CED.A.1, HSA-CED.A.2 HSA-CED.A.4,	
83	Electric Fields	MP.2, MP.4, HSA-SSE.B.3, HSA-CED.A.4	
87	Magnetic Fields	MP.2, MP.4, HSA-SSE.B.3, HSA-CED.A.1	
89	Forces in Materials		RST.11-12.7, WHST.11-12.2, 7
91	Summing Up	MP.2, MP.4, HSA-SSE.A.1, HSA-SSE.B.3	

7: DEFINITIONS OF ENERGY

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
94	The Physics of Work	MP.2, MP.4, HSN-Q.A.1	
95	The Work-Kinetic Energy Theorem	MP.2, MP.4, HSN-Q.A.1	
96	Stored Energy	MP.2, MP.4, HSN-Q.A.1	
97	Conservation of Energy	MP.2, MP.4, HSN-Q.A.1	
98	Pendulums	MP.2, MP.4	
99	Efficiency	MP.2, MP.4	
100	Review Your Understanding	MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2	
101	Summing Up	MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	

8: CONSERVATION OF ENERGY AND ENERGY TRANSFER

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
104	The Second Law of Thermodynamics	MP.2, MP.4, HSS-IS.A.1	
105	Modeling Energy Flow	MP.2, MP.4	
106	Work and Power	MP.2, MP.4	
107	Energy and Power Plants	MP.2, MP.4	
108	Energy Conversion Devices		WHST.11-12.2
110	Summing Up	MP.2, MP.4, HSN-Q.A.1	

9: WAVE PROPERTIES

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
112	Properties of Waves	MP.4	
113	The Speed of Sound	MP.2, MP.4, HAS-SSE.A.1, HAS-SSE.B.E, HSA.CED.A.4	
118	Digitizing Waves	MP.2, MP.4	

10: ELECTROMAGNETIC RADIATION

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
123	Evaluate Claim		RST.9-10.8, RST.11-12.7

11: INFORMATION TECHNOLOGY AND INSTRUMENTATION

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
132	Summing Up		RST.11-12.7, WHST.9-12.2

Teacher's Notes

Extended teacher's notes are found at the front of each chapter in the Teacher's Edition and Teacher's Digital Edition of *Physical Sciences for NGSS*. These notes appear immediately after the chapter introduction and provide context for the material and additional detail for the learning points (matched point for point). Where appropriate, opportunities to incorporate group work, practical activities, or design challenges are explained. Suggestions for differentiated instruction are also provided, including ways to support striving learners, e.g. through peer-to-peer support. For gifted and talented students we have included a "challenge question" and an associated image on the page immediately preceding or following the teacher's notes (see page CG11). Most activities are supported by material on **BIOZONE's Resource Hub**. The hub provides access to a large collection of free resources to supplement your teaching. Where they are provided, they are identified with a hub icon in the margin of both the Student Edition and Teacher's Edition. Where the resource is integral to the delivery of the activity (e.g. online data sets, computer simulations, or spreadsheets) we have indicated this in the teacher's notes.

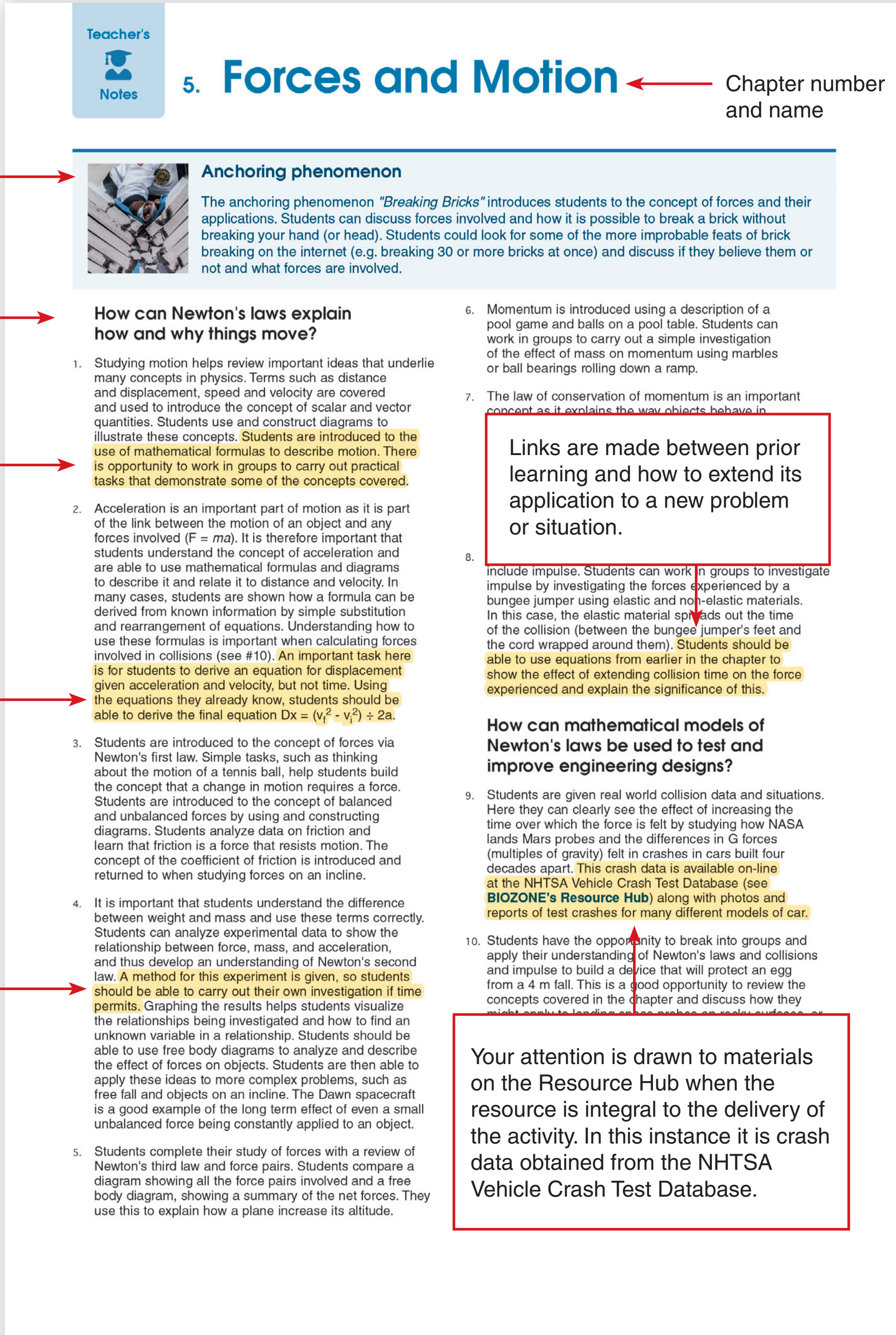
The anchoring phenomenon provides a context for the chapter. We have included some questions you may wish to ask your students to engage them in the topic and ideas for student engagement.

The guiding questions and numbering of learning aims is the same as in each chapter introduction of the Student Edition and Teacher's Edition (learning aims are matched point for point).

Opportunities for group work are identified. They provide opportunities for collaboration and can be used to develop ELA skills such as speaking and listening, developing language, and research and presentation skills.

Important learning aims, including when students need to understand and use significant equations, are specified.

Practical investigations or design challenges are identified. These can be used to deepen a student's understanding of a concept or idea. Practical activities are essential for developing competency over a range of science skills and help students to become comfortable working in a STEM environment.



Teacher's Notes

5. **Forces and Motion**

Anchoring phenomenon

The anchoring phenomenon *"Breaking Bricks"* introduces students to the concept of forces and their applications. Students can discuss forces involved and how it is possible to break a brick without breaking your hand (or head). Students could look for some of the more improbable feats of brick breaking on the internet (e.g. breaking 30 or more bricks at once) and discuss if they believe them or not and what forces are involved.

How can Newton's laws explain how and why things move?

1. Studying motion helps review important ideas that underlie many concepts in physics. Terms such as distance and displacement, speed and velocity are covered and used to introduce the concept of scalar and vector quantities. Students use and construct diagrams to illustrate these concepts. Students are introduced to the use of mathematical formulas to describe motion. There is opportunity to work in groups to carry out practical tasks that demonstrate some of the concepts covered.

2. Acceleration is an important part of motion as it is part of the link between the motion of an object and any forces involved (F = *ma*). It is therefore important that students understand the concept of acceleration and are able to use mathematical formulas and diagrams to describe it and relate it to distance and velocity. In many cases, students are shown how a formula can be derived from known information by simple substitution and rearrangement of equations. Understanding how to use these formulas is important when calculating forces involved in collisions (see #10). An important task here is for students to derive an equation for displacement given acceleration and velocity, but not time. Using the equations they already know, students should be able to derive the final equation $Dx = (v_f^2 - v_i^2) \div 2a$.

3. Students are introduced to the concept of forces via Newton's first law. Simple tasks, such as thinking about the motion of a tennis ball, help students build the concept that a change in motion requires a force. Students are introduced to the concept of balanced and unbalanced forces by using and constructing diagrams. Students analyze data on friction and learn that friction is a force that resists motion. The concept of the coefficient of friction is introduced and returned to when studying forces on an incline.

4. It is important that students understand the difference between weight and mass and use these terms correctly. Students can analyze experimental data to show the relationship between force, mass, and acceleration, and thus develop an understanding of Newton's second law. A method for this experiment is given, so students should be able to carry out their own investigation if time permits. Graphing the results helps students visualize the relationships being investigated and how to find an unknown variable in a relationship. Students should be able to use free body diagrams to analyze and describe the effect of forces on objects. Students are then able to apply these ideas to more complex problems, such as free fall and objects on an incline. The Dawn spacecraft is a good example of the long term effect of even a small unbalanced force being constantly applied to an object.

5. Students complete their study of forces with a review of Newton's third law and force pairs. Students compare a diagram showing all the force pairs involved and a free body diagram, showing a summary of the net forces. They use this to explain how a plane increase its altitude.

6. Momentum is introduced using a description of a pool game and balls on a pool table. Students can work in groups to carry out a simple investigation of the effect of mass on momentum using marbles or ball bearings rolling down a ramp.

7. The law of conservation of momentum is an important concept as it explains the way objects behave in

8. include impulse. Students can work in groups to investigate impulse by investigating the forces experienced by a bungee jumper using elastic and non-elastic materials. In this case, the elastic material spreads out the time of the collision (between the bungee jumper's feet and the cord wrapped around them). Students should be able to use equations from earlier in the chapter to show the effect of extending collision time on the force experienced and explain the significance of this.

How can mathematical models of Newton's laws be used to test and improve engineering designs?

9. Students are given real world collision data and situations. Here they can clearly see the effect of increasing the time over which the force is felt by studying how NASA lands Mars probes and the differences in G forces (multiples of gravity) felt in crashes in cars built four decades apart. This crash data is available on-line at the NHTSA Vehicle Crash Test Database (see **BIOZONE's Resource Hub**) along with photos and reports of test crashes for many different models of car.

10. Students have the opportunity to break into groups and apply their understanding of Newton's laws and collisions and impulse to build a device that will protect an egg from a 4 m fall. This is a good opportunity to review the concepts covered in the chapter and discuss how they

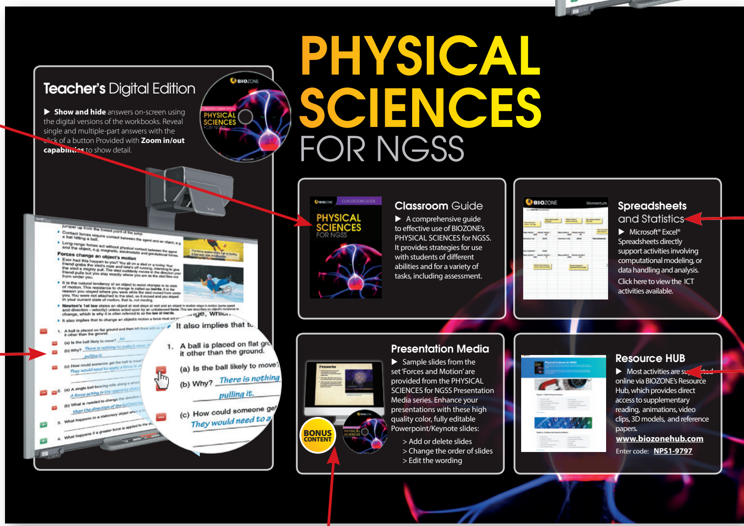
Chapter number and name

Links are made between prior learning and how to extend its application to a new problem or situation.

Your attention is drawn to materials on the Resource Hub when the resource is integral to the delivery of the activity. In this instance it is crash data obtained from the NHTSA Vehicle Crash Test Database.

The Teacher's Digital Edition

The *Teacher's Digital Edition* is a DRM product, sold separately, and aimed primarily at extending the pedagogical tools at a teacher's disposal. Many of the features of this resource have been developed in response to requests from teachers themselves.



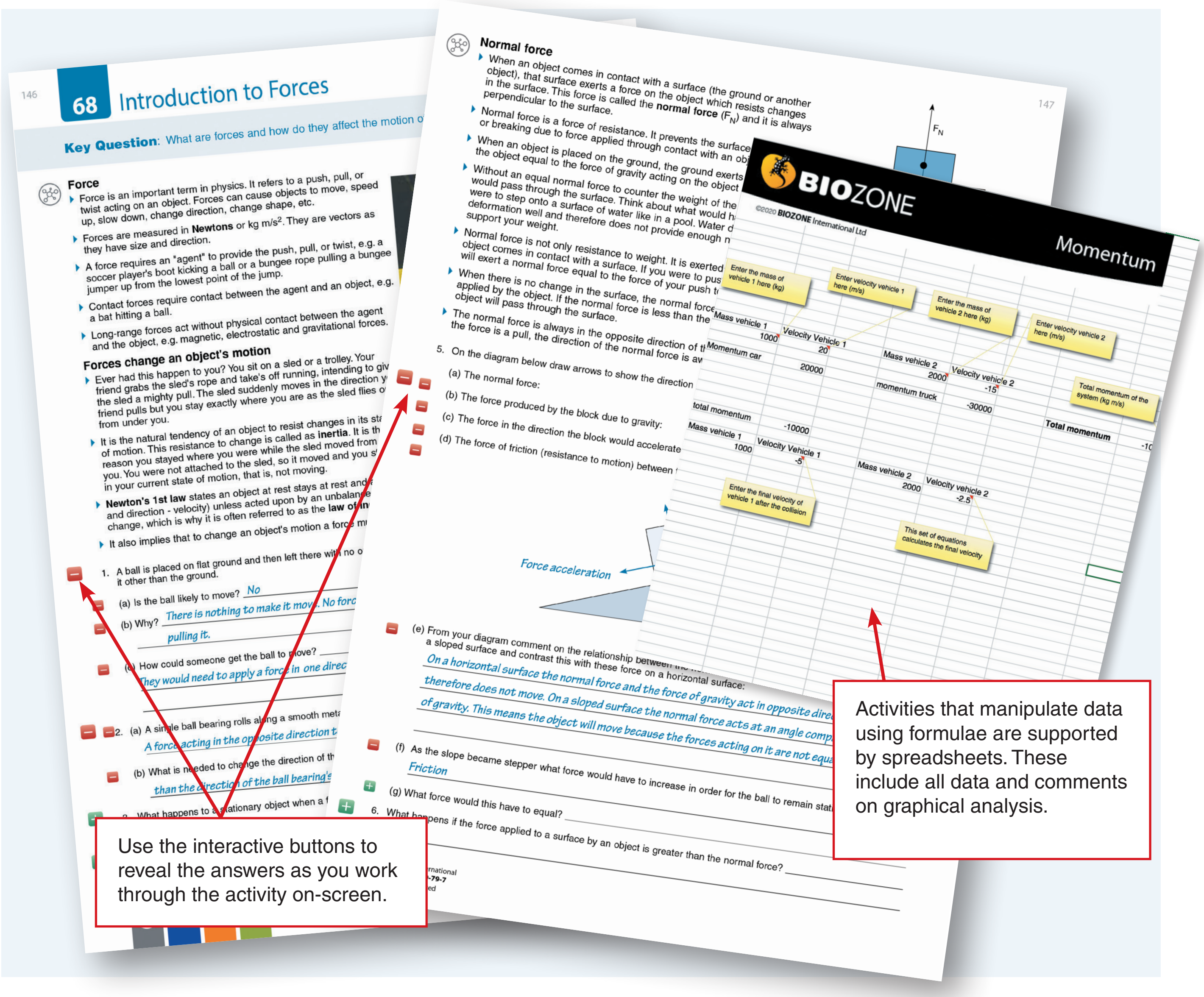
The **Classroom Guide** is provided as a printable PDF.

A digital (PDF) version of the Teacher's Edition (non-printable) is provided. Use the interactive buttons to HIDE or SHOW the answers.

Link to ***Excel***® **spreadsheets** for selected activities with a data analysis or computer modeling component.

Access **BIOZONE's Resource Hub** directly from this link for a range of resources to support the activities.

A **BONUS** sample copy from the planned presentation media for *Physical Sciences for NGSS*. It is fully editable.



Activities that manipulate data using formulae are supported by spreadsheets. These include all data and comments on graphical analysis.

Use the interactive buttons to reveal the answers as you work through the activity on-screen.