High School Science Lesson Plan: Physics

Introduction
Each lesson in the Adolescent Literacy Toolkit is designed to support students through the reading/learning process by providing instruction before, during, and after reading/learning.

Note that lessons incorporate the *gradual release of responsibility* model. When this model is used within a single lesson and over several lessons, students are provided with enough instruction and guidance to use the literacy strategies on their own. The following lesson includes some examples of explicit instruction and modeling, guided practice, and independent practice, but students need more practice and feedback than is possible within the context of a single lesson.

Bold print indicates a direct link to the *Content Area Literacy Guide* where readers will find descriptions of literacy strategies, step-by-step directions for how to use each strategy, and quadrant charts illustrating applications across the four core content disciplines.

The following lesson plan and lesson narrative show science teachers how they can incorporate the use of literacy strategies to support high school students to learn physics content and concepts. The lesson is designed for one block period (80–90 minutes) or two traditional classes (50 minutes).

Instructional Outcomes

ISTE Standards: A1. Identify questions and concepts that guide scientific investigations; formulate and revise scientific explanations and models using logic and evidence. A2. Scientists usually inquire about how physical, living, or designed systems function. B4 Motions and forces.

Content Learning Outcome: Students will activate their prior knowledge about, deepen their understanding of, and compare/contrast primary principles of physics/mechanics: *center of gravity; rotation; universal gravitation; gravitational interactions; satellite motion; special relativity of space and time;* and *special relativity of length, momentum, and energy.*

Literacy Support Strategies and Instruction

Before reading/learning: **Frayer Model** (teacher modeling)
- Material: Text chapter on Circular Motion

During reading/learning: Reading of related text
- Materials: Short text selections about specific physics/mechanics principles: *center of gravity, rotation; universal gravitation; gravitational interactions; satellite motion; special relativity of space and time;* and *special relativity of length, momentum, and energy*

After reading/learning: **Frayer Model** (small group practice)
- Materials: **Frayer Model Template**, large posters, markers, masking tape

The content for this component of CCSSO's Adolescent Literacy Toolkit was provided by Public Consulting Group's Center for Resource Management, in partnership with the Council of Chief State School Officers (August 2007). The content was informed by feedback from CCSSO partners and state education officials who participate in CCSSO's Secondary School Redesign Project.

Before Reading/Learning (20 minutes)

Literacy outcome: Students will see how the **Frayer Model** can be used to analyze, understand, and define a concept by deriving essential characteristics from examples and applications.

Teacher preparation (before delivering the lesson): Pre-read the text selection on Circular Motion and create a **Frayer Model** to illustrate how text information can be entered into the four quadrants of the organizer.

- Modify the example below to fit the content of the actual text selection students will read.
- Plan how you will project the example so you can explain it to the class.

Example of a **Frayer Model Template** for *Circular Motion*:

Essential characteristics (Has to have or be)	**Non-characteristics** (Can not have or is not)
• Number of rotations per unit of time • All parts rotate at the same speed, but the distance from the center affects linear (tangential) speed • Centripetal force is a center-directed force that produces circular motion • Centrifugal force is an effect of rotation • Gravity is simulated by centrifugal force	• Motion in lines • Weight or size of the rotating object • Force and time intervals (impulse) • Change in momentum • Gravity • Elliptical orbit • Time dilation
Circular Motion	
Examples	**Non-examples**
• Swinging a can on a string in a circle • Earth's rotation • Hamster running in a cylinder • Horses on a merry-go-round • Astronauts in a rotating space station • Ice skater doing a pirouette • Race car turning through a curve on a track	• Things that move along a line • A swimmer in a race • The path of a bullet • An apple falling from a tree • The light path from a projector to a screen • A car passing another car on a road • An astronaut being weightless in orbit

Definition in my own words: Circular motion is rotation along a path that forms a circle because a moving object is affected by a centripetal force which pulls it towards the center of the circle.

Teacher facilitation:

1) Tell students that a **Frayer Model** is a graphic organizer strategy they can use to help them define and improve their understanding of technical vocabulary or concepts.
   - Explain that the organizer has four quadrants: *Essential characteristics, non-characteristics, examples,* and *non-examples.*
2) Re-create your prepared **Frayer Model** example on the board "from scratch" to show the students how it is completed.
   - Explain how you located or added your own examples or non-examples based on your own experience. Ask students to contribute their own examples.
   - Go page by page through the circular motion text selection and model how to locate information about the characteristics and non-characteristics. As students see how you locate them, ask them to find the next ones.
3) Explain how to create a good definition by summarizing the key characteristics of the mechanics principle (in this case *circular motion)* and then checking the definition

against the examples to make sure it makes sense.
- Ask pairs of students to create a definition based on the **Frayer Model**.
- Ask for volunteers to share the definition they created.
- Share the definition you created with the class.

4) Project or draw a **Frayer Model** for the students to get more practice. Place the concept, *center of gravity*, in the center of the **Frayer Model**.
   - Ask students to scan the text to find one essential characteristic. Record one or two examples.
   - Guide students with locating or determining one non-characteristic and record.
   - Complete at least one item for *examples* and *non-examples* as a guided activity.
   - Ask students to work with a partner to complete the **Frayer Model** items and develop a definition together.
   - Orally review student findings and record on the **Frayer Model** example before directing students to work with the remaining concepts.

During Reading/Learning (35 minutes)

Literacy outcome: Students will read a text selection to form a general understanding of a physics mechanics concept in preparation for defining it by using the **Frayer Model**.

Teacher facilitation:

1) Assign an equal number of students to read about one of the remaining concepts: *rotation; universal gravitation; gravitational interactions; satellite motion; special relativity of space and time;* or *special relativity of length, momentum, and energy*.
2) Tell them that after reading they will work with others who have read about the same principle to build a **Frayer Model** of the essential characteristics and examples like the class just did with the principles *circular motion* and *center of gravity*.
3) Have students independently read or use **Paired Reading** to read information in the chapter related to the specific mechanics principle.
   - Ask students to take notes as they read to prepare for the group discussion.
   - Pass out blank **Frayer Model Templates** and encourage students to take notes on it as they read to prepare for the group discussion.

After Reading/Learning (45 minutes)

Literacy outcome: Students will collaboratively define a complex concept by constructing a **Frayer Model** about a specific mechanics principle described in the text.

Teacher facilitation:

1) Ask students to form small groups with other students who read about the same principle: *rotation*; *universal gravitation*; *gravitational interactions*; *satellite motion*; *special relativity of space and time*; or *special relativity of length, momentum, and energy*.
2) Explain that each small group will review the text selection and their notes to collaboratively complete a group **Frayer Model Template** for their concept.
   - Pass out a template for the **Frayer Model** to each group.
   - Ask each group to select a note taker.
   - Remind students they should also include information from their prior reading or study of physics and real life examples of the concept in action.
   - Ask each group to develop a definition of the concept after completing the **Frayer**

Model Template.

3) Circulate as groups discuss the text to assist them in completing their **Frayer Model**.
4) Have each group create a wall poster of their completed **Frayer Model** and display it on the classroom wall.
5) Ask students to do a *Gallery Walk* and asterisk the concepts in each quadrant they think are most important. These activities will engage students in learning about each mechanics concept, as well as see how the other groups completed the **Frayer Model**.

Note: To gain a better understanding of how to organize this group activity, read more about the **Jigsaw** strategy in the *Content Area Literacy Guide* section of the CCSSO *Adolescent Literacy Toolkit.*

High School Physics Lesson Narrative: Circular Motion

Teachers: As you read the lesson narrative, think about the following questions. You may want to discuss them with fellow science teachers.

- *What does the teacher do to support students' literacy development and content learning before, during, and after reading/learning?*
- *What challenges do you anticipate if you were to implement this lesson in your own classroom? How would you prepare to meet these challenges?*
- *How would you make improvements to this lesson?*

Mr. Lowell really enjoyed helping his physics students see how understanding nature's basic principles can enhance one's perspective about the world around us. But students always relied on him to frontload information before each unit and to provide vocabulary definitions. Assigning vocabulary definition exercises did not seem to help. Many students did not remember the vocabulary or understand major concepts any better and some did a cursory job with the definitions, if they did them at all. A colleague had mentioned a strategy called the **Frayer Model** had worked well in her class. Mr. Lowell went online to learn more about it and decided to try it to help students understand and define difficult physics/mechanics concepts.

Before Reading/Learning

During the first weeks of the semester Mr. Lowell had used many demonstrations, labs, and lively discussions about real-life and futuristic applications to build students' confidence about learning physics. Now, he thought to himself, I have to get them to be more independent in their learning. "Today you will read about one principle of mechanics, such as gravity, motion, or relativity. Then you'll work with a small group to define the principle using examples and characteristics." "Uh-oh," loudly whispered Sharon to her friend, "The fun's over. I told you this class would get a lot harder." Mr. Lowell smiled and said, "No, it's going to be easier than you think, because you'll be working collaboratively, and I'm going to teach you a great vocabulary strategy that helps you understand words and concepts by linking real-life situations to the physics terms."

He continued, "We'll take it step-by-step. I know many of you agree with Sharon, that it's pretty hard to read and understand our textbook. Sometimes it's hard to understand a physics principle by reading a complicated definition that doesn't make sense at first. The strategy I'm going to model for you, called the **Frayer Model** after the guy who invented it, helps you define complex terms and concepts by thinking of real-life examples and non-examples of an idea in order to figure out its characteristics. I'll show you step-by-step how to do it on the board.

Mr. Lowell drew the **Frayer Model** quadrant chart on the board with the term *circular motion* in the middle as he continued. "Say you have no idea what's involved with circular motion, but you do know what a circle is and you know what motion is. So start by thinking of where in life things move in circles." He showed them how, in the bottom left box, he had thought of several real-life examples of things that spin or move in a circle. "Can you think of other circular motions?" After a short pause, a few students contributed ideas, ranging from a dog chasing its tail to a gear turning in an engine. As he added their ideas to the chart, he said "Great ideas, that's exactly how to do the first part. Think about and list real-life examples that seem to fit the topic. Next, think about opposites—what are some motions that are not circular? For example, things that move in a straight line like a swimmer in a race. To his surprise, Sharon shyly raised her hand and said, "A kid throwing a coin into a fountain?" "You got it!" he responded.

With students looking at the text chapter with him, he explained how he reviewed the chapter to deepen his understanding about circular motion so he could complete the quadrants on the **Frayer Model** chart. “Here’s what I was thinking as I filled in the chart. When the text stated that *circular motion involves a number of rotations per unit of time*, I asked myself if I could count a unit of time for all the things on my examples list, and I found that, yes, this idea applies to everything on the list.” He said they should check each characteristic against the real-life examples to understand the technical characteristics of the mechanics principle. “For example, I got confused when I read *all parts rotate at the same speed, but the distance from the center affects linear speed.* Then I compared it to horses on a merry-go-round and realized the horses on the outside travel more than the horses on the inside, even though they rotate in the same circle.” To his relief, he saw several students nodding as he explained how to connect the characteristics of the principle to real-life examples. He then explained how he looked at the non-examples to help him determine some of the things circular motion can not have or can not be. He concluded by explaining how he then put it all together in his own words to form a definition of the concept of circular motion.

Mr. Lowell knew the students needed more guidance before releasing them to work with a partner; so he decided to draw another **Frayer Model** with the concept *center of gravity* in the center. He asked the students to scan the text to find at least one essential characteristic and, as the students began to locate and raise their hands, he called on Mary, who said it is the average location of the weight of an object. He asked if the other students agreed with her finding. Seeing students nod, he asked if anyone could provide a specific example of what this means. He encouraged the students to look at some of the pictorial examples found within the text. Johnson said, “There is a picture of a hinge, but I am not sure why it would have a center of gravity.” Mr. Lowell asked if there was anyone who could explain this example. Seeing that no one could, he used the door in the room to demonstrate how the hinge rotated around its center of gravity when the door is opened and closed. After this demonstration, Mr. Lowell asked if this helped the students to identify other essential characteristics of *center of gravity.* The discussion continued as Mr. Lowell continued to work with the students to identify information to complete the **Frayer Model**.

During Reading/Learning

He continued, “There are a number of mechanical principles we’ll be learning about in this unit. To make it easier for each of you, each group will read about and complete a **Frayer Model** chart about only one of the principles. “Whew,” called out Tommy. “I thought you’d make us read this whole chapter.” “No, each group will read a section and help the others understand the principle through a discussion of their finished chart.”

After assigning groups of students to read about one of the remaining principles, he continued the directions. “The **Frayer Model** is a great tool and, like any new tool, it takes some practice to use it correctly. Since it’s your first time, you’ll work in small groups so you can share your thinking and find solutions to any obstacles as you work together. I’d like you to take notes to prepare for that discussion, so I’m passing out the **Frayer Model Template** now.

Slowly the students quieted as they located the appropriate section in the textbook chapter and most began to read. Mr. Lowell moved around the room to check in with a few students who appeared to be staring at the book pretending to be reading. Quietly he encouraged them to read the selection, ask questions of one another, review the graphics and photos, and be ready to talk with their groups.

After Reading/Learning

Next Mr. Lowell reviewed the steps in completing the **Frayer Model** and asked for questions. "How did the **Frayer Model** help you to understand these new concepts? What confusions remain?" When one student queried, "How will we know if the non-characteristics are correct?" Mr. Lowell referred to the **Frayer Model** sample for circular motion. "Note the cue on the chart: *Can not have* or *is not.* Check your answers against the examples. Can a swinging can on a string move in a straight line? Can the earth? Can the horse on a merry go-round? If the answer is no for every example, then you know your non-characteristic is correct."

"So here's what's next," he continued, "in your group you'll draft a **Frayer Model** chart for your mechanics principle. Be sure to write the summary conclusion at the bottom. Then you'll copy it onto a large poster. During the last 15 minutes of class, we'll hang up all the posters and do a quick *Gallery Walk* where all of you will circle the room to read the posters and mark the ideas you think are most important."

After he suggested they select one person to serve as the group leader to keep them focused, and another person to write the notes on the **Frayer Model** template and create the wall poster, most students settled down and began completing the chart, sharing their ideas, and scanning the text to locate more information. Most groups seemed on task. Mr. Lowell worked with two groups who seemed to be floundering, helping them brainstorm real-life examples of their principle. He saw the examples triggered some enthusiasm in normally disinterested students. He wasn't asked to repeat the directions as often as usual. Modeling my own thinking and showing them a completed example seemed to help them understand how to use the **Frayer Model**, he reflected.

After they created the wall charts, the class was quite animated but attentive as they rotated around the room, discussing and identifying what they saw as the most important points on the **Frayer Model** posters. He knew this lesson was just the beginning to understanding these complex principles. Just a start, he reminded himself, but with time and practice, maybe students will be able to do more on their own and depend less on me. As students exited, he thought he'd have them do informal paired presentations tomorrow using the **Frayer Model** posters to review the concepts more carefully.