Collisions and Momentum in 1D

Teacher's Guide

1.0 Summary

Collisions and Momentum in 1D is the sixth activity in the Dynamica sequence. This activity should be done after *Force in 2D* and it should take students approximately 20 minutes. This is a fairly basic activity that only includes collisions on the x-dimension. The activity gives students a solid foundation for *Advanced Collisions,* the next activity in the sequence.

2.0 Learning Goals

Driving Question: When two items collide, what happens to their velocities?

This activity presents a model of two balls colliding and asks students to figure out the rules for what happens to the ball's respective velocities when they collide.

Step One: **Balls of the Same Mass** introduces students to collisions by observing collisions of pool balls of the same mass. Students are introduced to linear momentum and the equation p=mv.

Step Two: **Balls of Different Masses** encourages students to predict what different masses do when they collide. This section also allows students to discover the rules for final velocities when each ball has a different mass.

Step Three: **The Law of Conservation of Momentum** introduces students to this law. Students learn how to calculate the total momentum for a system both before and after a collision. Then, students are given various experiments to test the law.

Step Four: **The Mystery Ball** section has one ball colliding with a mystery ball. Students must observe the collision, look at a data table and draw conclusions about the mass of the hidden ball.

Step Five: **Quiz** contains three questions meant to ensure that students understand the basic concepts of collisions.

Additional Teacher Background

This activity is somewhat abstract. The few situations in the visible world where objects collide and neatly exchange velocities may seem contrived. But it's a worthwhile exploration for a number of reasons:

- Students get used to noticing the conditions before and after an event.
- Students do math involving both positive and negative velocity.
- The activity leads toward momentum and how it enables one to deal with different masses.

- The notion of a *conservation law*, where some quantity (in this case velocity) is the same before and after an event, is a very important tool in physics. Understanding the conservation of energy (see the *Energy* activity) is especially valuable.

- The use of a law (such as exchange of velocities) is often used to infer a quantity that cannot be measured directly - in this case, the velocity of a hidden ball.

Additional Activities

Collisions: Use two sonar rangers to explore the before-and-after velocities of low-friction carts. If the masses are equal, do they exchange velocities? If not, can you explain why not?

3.0 Standards Alignment

Alignment to National Math and Science Standards (NCTM or NSES)

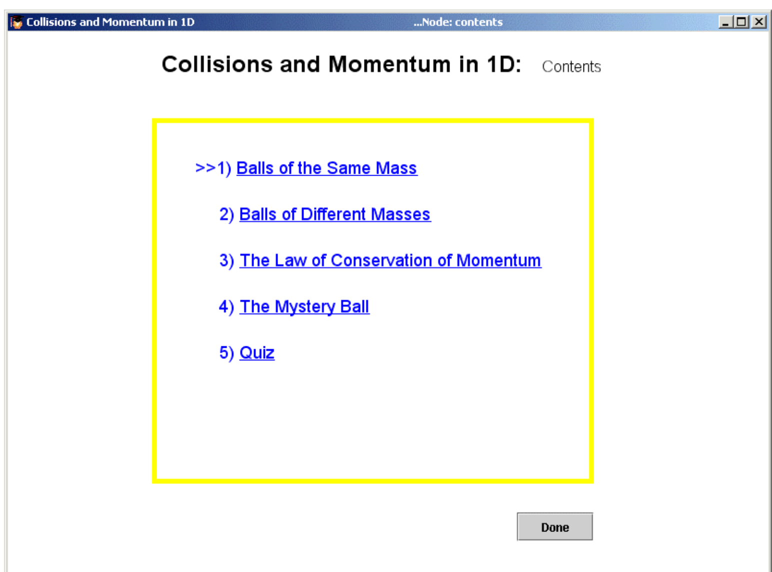
Objective	Standards
Students will discover rules for collisions by doing experiments.	• Students should draw reasonable conclusions about a situation being modeled. • Students should use the language of mathematics to express mathematical ideas precisely. • Students should recognize and apply mathematics in contexts outside of mathematics.
Students will understand the meaning of positive and negative velocity.	• Students should use the language of mathematics to express mathematical ideas precisely.
Students will use the conservation of velocity rule in collisions of equal masses.	• Students should draw reasonable conclusions about a situation being modeled. • Students should make and investigate mathematical conjectures.

Opening screen

4.0 Activity Sections

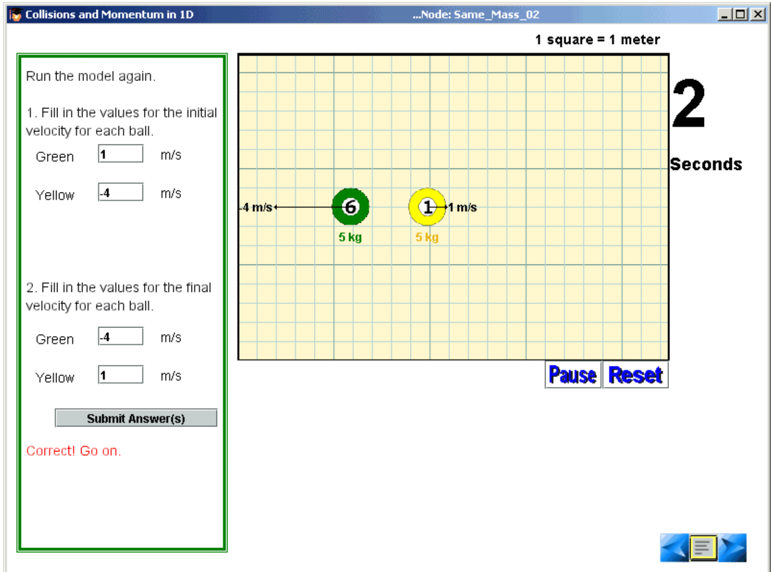
4.1 Table of Contents

This activity has 7 sections. The required sections of this activity are sections 1 through 6. The last section is a “Lab” within which teachers may assign students custom experiments.

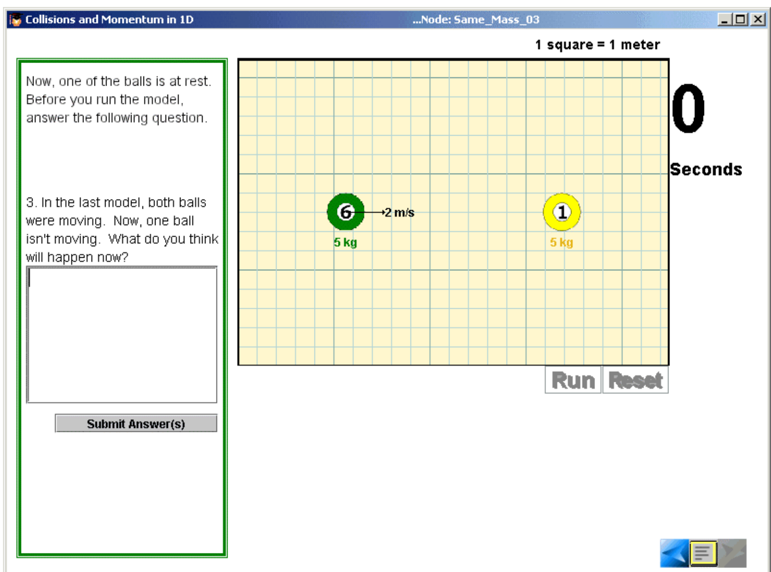


4.2 1) Balls of the Same Mass

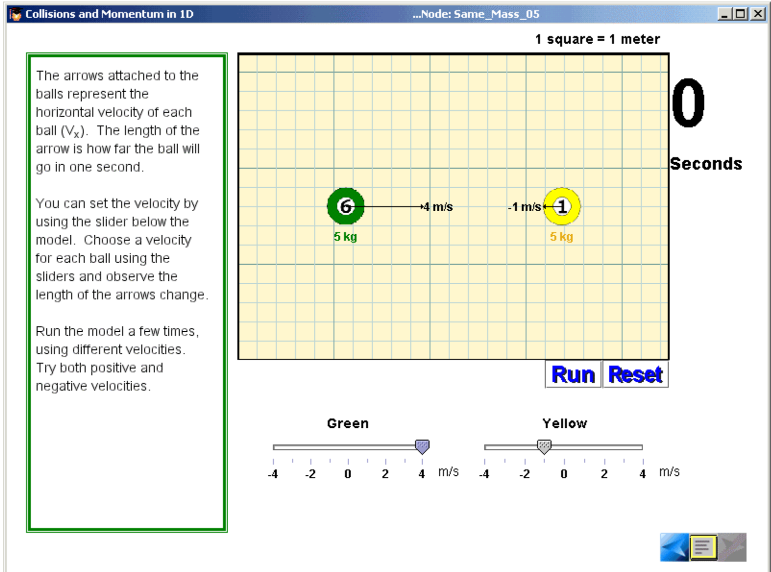
In this section, students run models and observe that when two objects of the same mass collide, they exchange velocities. Of course, the model depicts a frictionless environment.



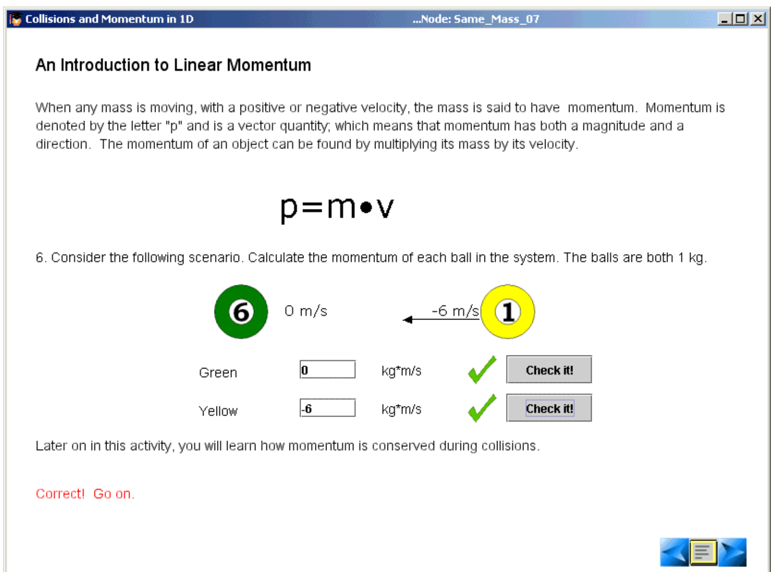
Model showing the exchange of velocities



Students are asked to predict what will happen with one ball at rest.



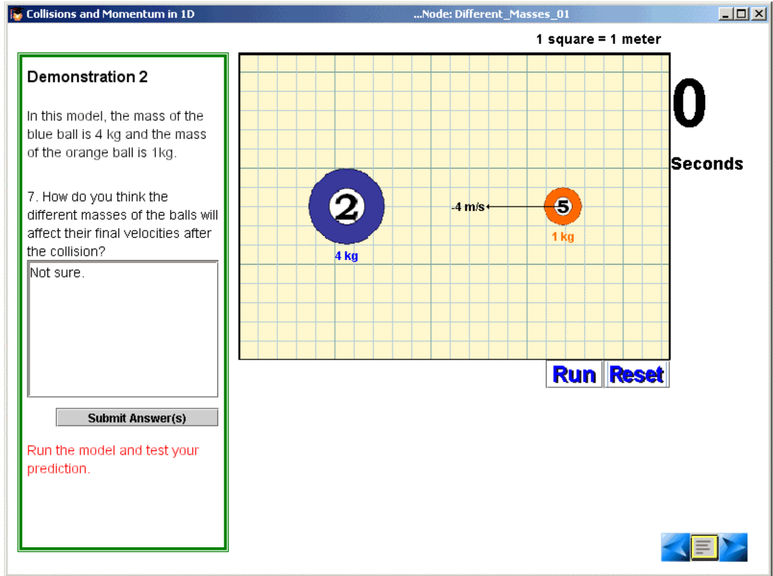
Students experiment with initial velocities.



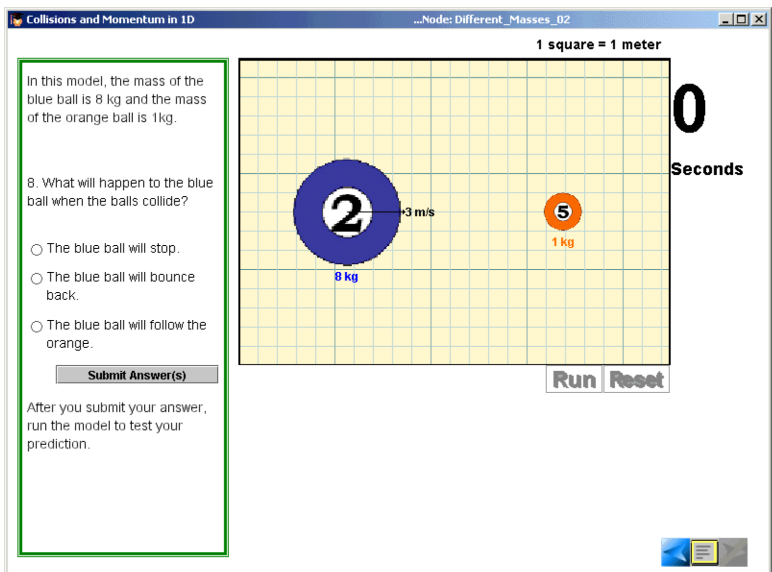
Introduction to linear momentum

4.3 2) Balls of Different Masses

In this section, students run models of collisions with two balls of different mass. First, they are asked to predict what will happen after the collision. Then, they are guided though various scenarios.



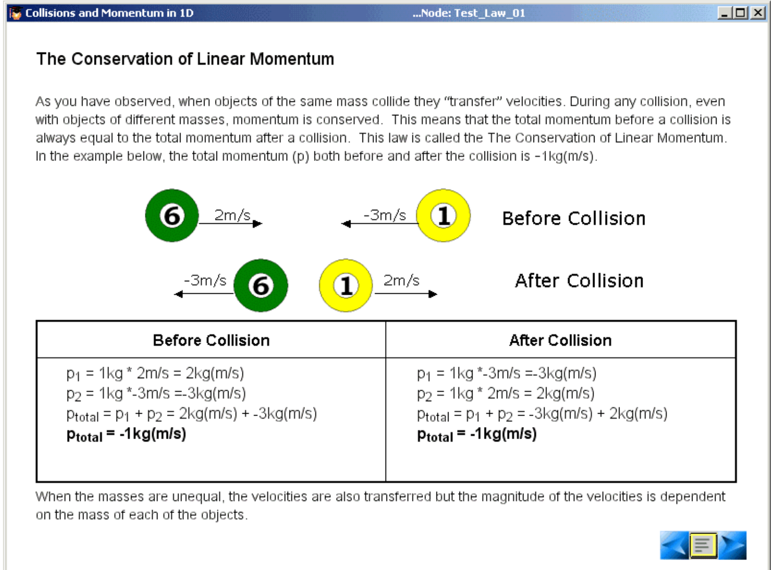
Run the model and examine the graphs.



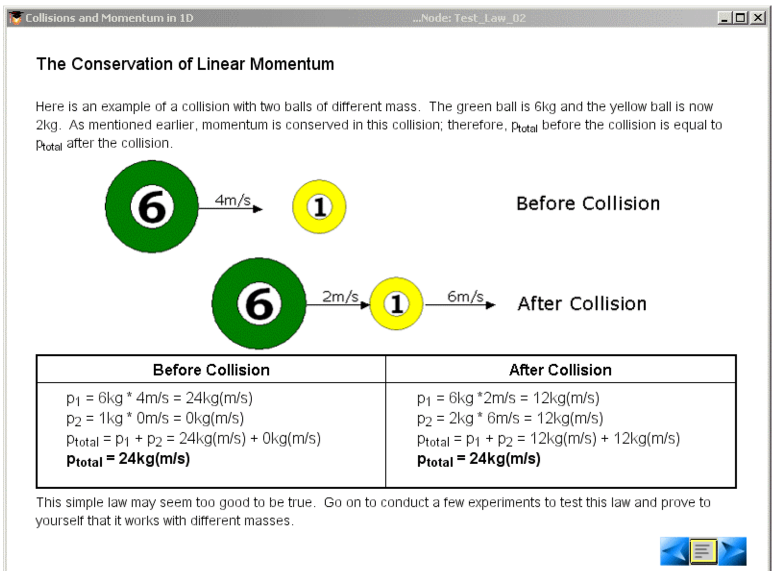
The student is asked to predict the result of this collision.

4.4 3) The Law of the Conservation of Momentum

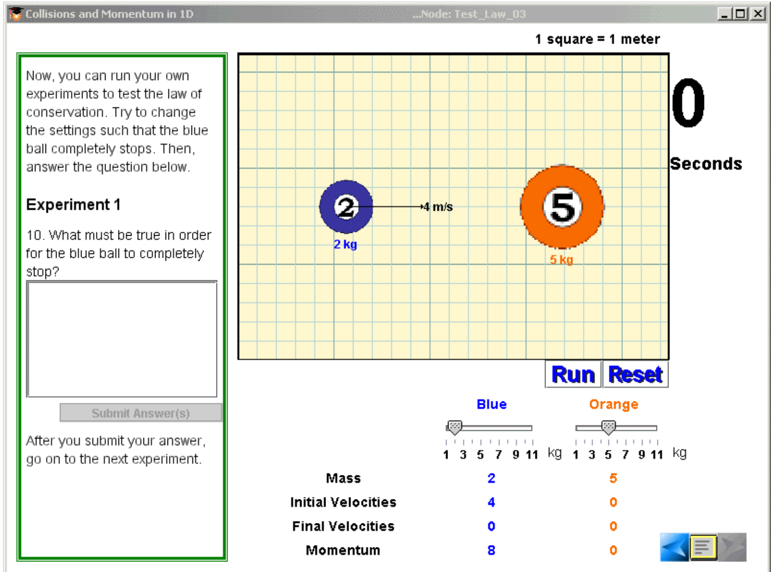
This section helps students better understand the Law of Conservation of Momentum. In this section, students learn to calculate the total momentum of a system both before and after a collision. Then, they are given three experiments to conduct that "test" this law.



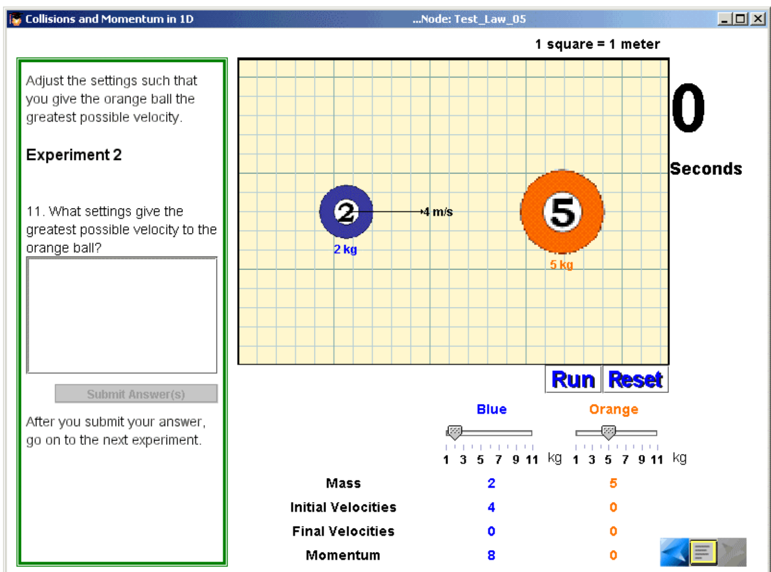
The law as applied to objects of the same mass



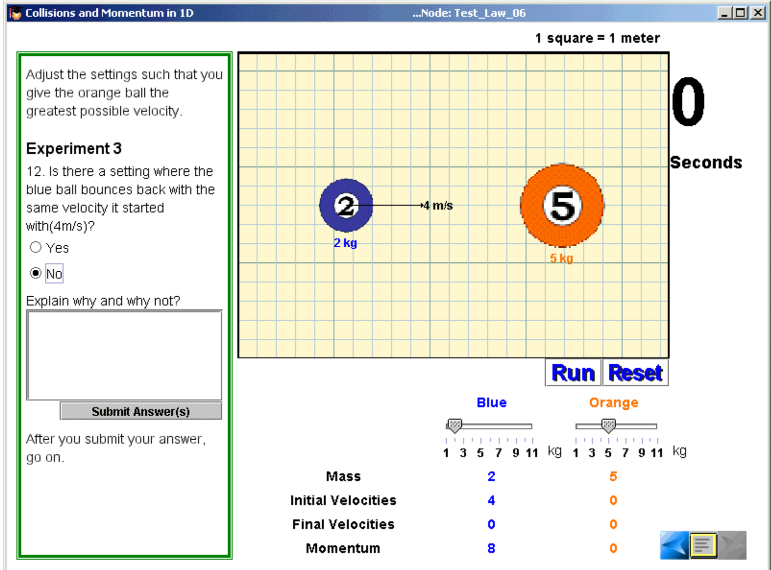
The law as applied to objects of different mass



Experiment 1



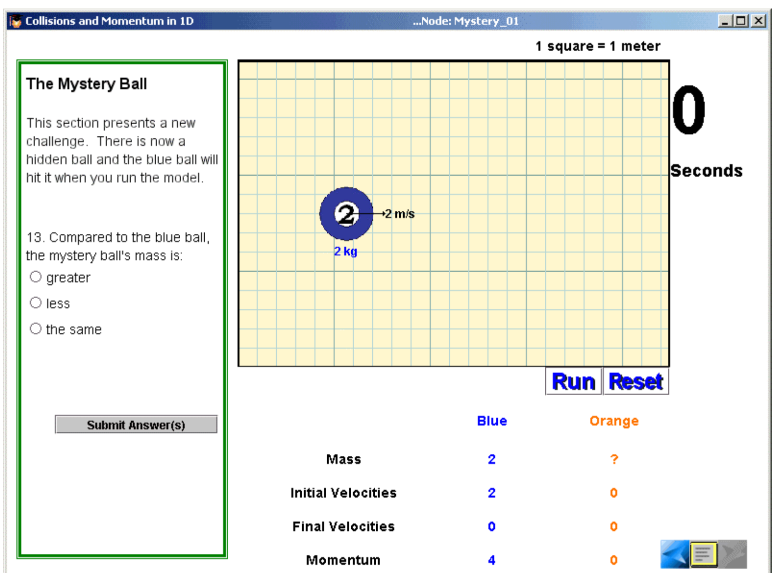
Experiment 2



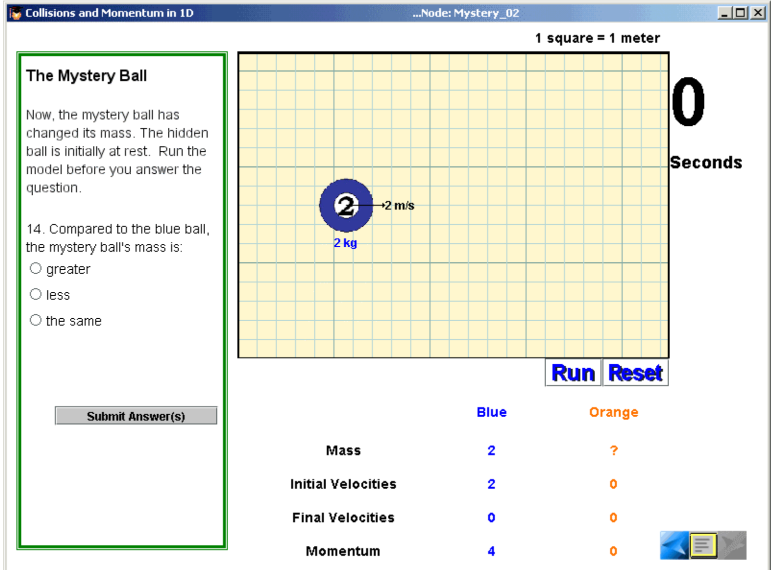
Experiment 3

4.5 4) The Mystery Ball

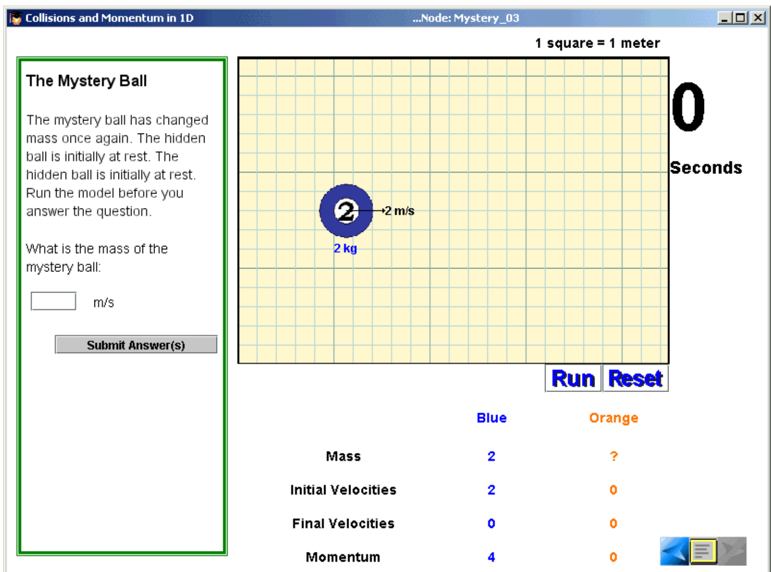
Now, students observe a collision with a hidden ball. Students are asked to run the model and, based on their observations, determine the mass of the hidden ball.



First scenario- the hidden ball's mass is less than the blue ball.



Second scenario- the hidden ball's mass is greater than the blue ball.

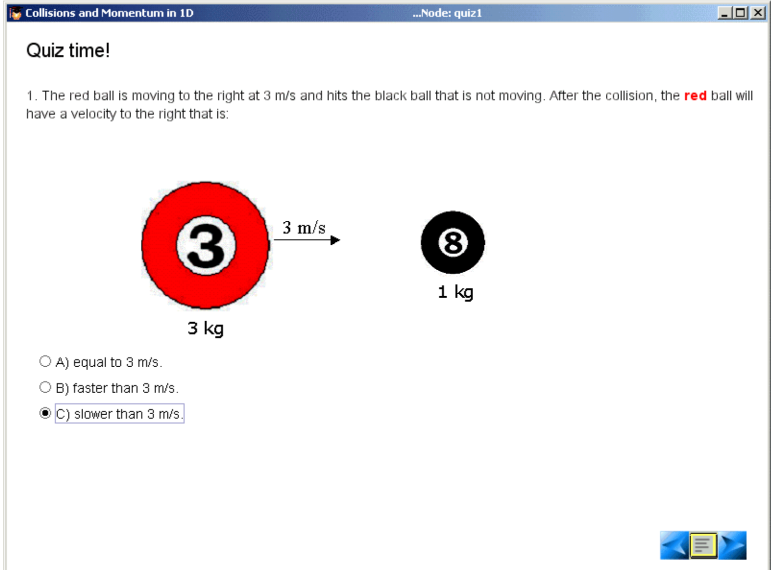


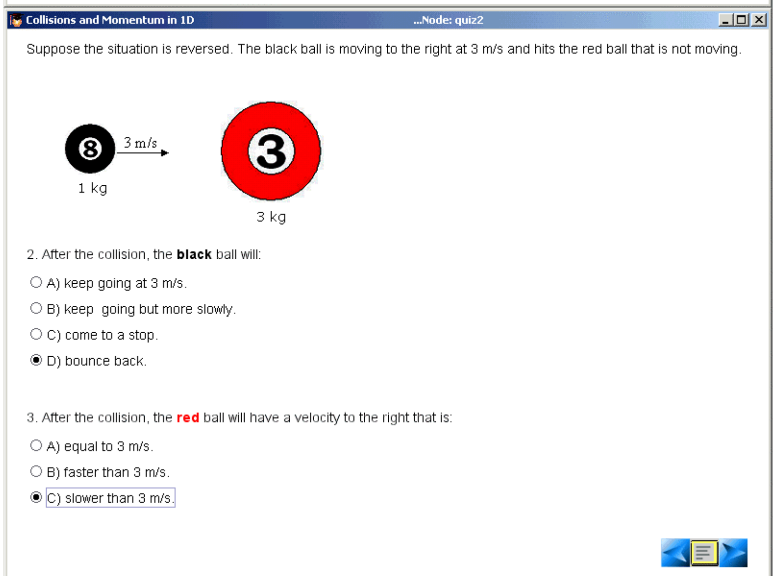
Third scenario- the hidden ball's mass is equal (2kg) to the blue ball.

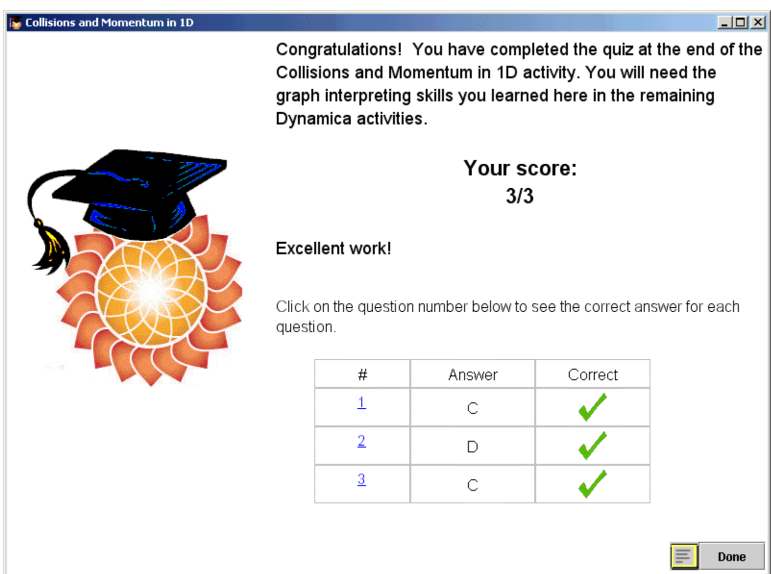
4.6 5) Quiz

This assessment contains three questions. At the end of the quiz, students will see their total score. In addition, they will be able to review the questions and see the correct answers to any question that they may have answered incorrectly.

Correct answers: 1-C 2-D 3-C







Students can review correct answers by clicking on the question numbers.

5.0 Student Reports

Your students' work with the *Collisions and Momentum in 1D activity* is logged and viewable on the MAC Project Web Portal at http://mac.concord.org. For each student, you can view a report containing questions and student answers.

The next activity in the sequence should be *Advanced Collisions*.