Elastic Collisions

Subject Area	Physics.
Age or Grade	Elementary high school physics.
Estimated Length	Two 45-minute lessons. The second lesson gives the students time to finish the worksheet, as well as time for the teacher to lead a discussion and note-taking on elastic collisions based on the students' discoveries.
Prerequisite knowledge and skills	Kinetic and potential energy, energy conservation, impulse, the momentum equation ($p=m \cdot v$).
Lesson Goals and New Content	The students explore momentum conservation and elastic collisions. At the end of the second lesson, they should have a basic understanding of what momentum conservation means, and of what an elastic collision is (in particular that it conserves both momentum and energy).
Materials Needed	Newton's Cradle. Worksheet.
Procedure	**Opener** (~5 min.) Divide the students into groups of 2-3. Bring out Newton's Cradle and challenge the students by pulling one ball to the side and asking them if they can predict what will happen when you let go. Give them a few minutes to talk it over in their groups. (Most will probably know the answer, even if they don't know of the physics involved.) Afterwards, go over with them what they think is going to happen.

	Development (~55 min.) Do the first demonstration (page 1) with the class. (You can do it once for everyone to see, and then walk around in the groups and show it in more detail.) The students should realize that one ball rises on the other side, and that it rises to the height from which the first ball was released. Then, let them work through the questions on the first page. Walk around and help them if problems arise, but otherwise let them work together in their groups. As groups finish the first page, bring over the cradle once more, and have them discuss what they think will happen when two balls are dropped. Even though most will probably guess that two balls will rise to the same height on the other side, suggest to them that perhaps only one swings out, but to a higher height. This is of course the wrong answer, but it serves as something to disprove through the following problems. Let them work through the back of the page in their groups. **Closure** (~30 min.) Consult with the class what they found in the different cases. (Start with page 1.) Draw a schematic on the board, and make a table that lists both the momentum and the kinetic energy of the balls before and after the collision. Emphasize that (as the students will have seen from their work) both energy and momentum is conserved in this case. Now go over the first three parts of page 2 in the same wav. As before. vou should reach the

	conclusion with the students that momentum was conserved in this case as well. Now, address the last part of page 2. Conclude that both momentum and energy were conserved during the collision. Finally, you're ready to formally introduce the term "elastic collision" as a collision in which objects bounce off each other, and in which both momentum and kinetic energy are conserved. Since the students know that the momentum of a single object is $p \cdot v$, you can now use that combined with their new knowledge of momentum conservation to arrive at the momentum conservation equation for two objects colliding elastically.
Evaluation	This homework set practices their knowledge of impulse and collisions. This class worksheet goes over both elastic and inelastic collisions and emphasizes how one conserves kinetic energy, while the other does not.
Extensions	Newton's cradle can be used to further illustrate elastic collisions. For example, you can examine with them what happens when you raise three balls, one on each side, two on one side and one on the other, three and two, etc. This lesson should be either followed or preceded by a discussion of inelastic collisions.