Happy/Sad Ball

Amount of time Demo takes: 5-6 minutes

Try this in the classroom!

Lesson's Big Ideas

- These polymer balls look similar, but they behave differently. They demonstrate the conservation of momentum in elastic and inelastic collisions.

Materials

- Chem stand with crossbar (stand base, upright pole, crossbar, clamp)
- Four happy and sad balls (2 on strings)
- Blocks (1 with happy face, 1 with sad face)

SAFETY!

- **Safe demo!**

Background Information

- A happy ball is a ball that bounces while a sad ball does not (illustrate by dropping them side-by-side on the tabletop). These polymer balls look similar but they behave differently.
- This lesson is about momentum changes in a collision and how total momentum must be conserved. A misconception is that the collision will take less force to bounce off (elastic) than to stick together (inelastic). This **isn't** true because bouncing involves a larger total force to both stop the current motion and reverse it.
- Looking at each ball's momentum before and after the collision will show this. Both balls have the same mass and were released from the same height, meaning that at the point just before impact they have the same momentum. After the collision the sad ball has stopped up against the board, meaning that its momentum is now zero.
- In the case of the happy ball, it bounces away, meaning that it now has a "negative" (opposite-direction) velocity compared to when it was going in. The total change can be represented as:

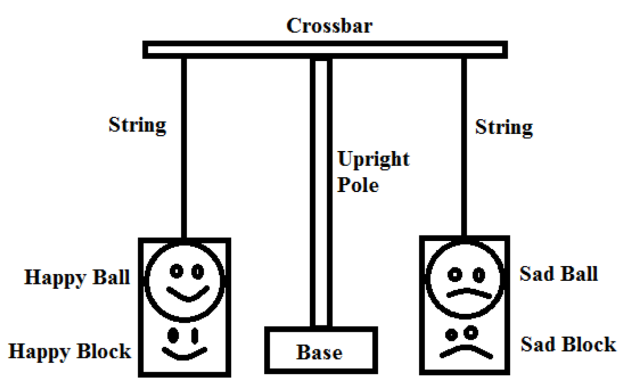
$m\ v_{(old)} + m\ v_{(new)} =$ (total change of the block)
where m is mass and v is velocity

So, the happy block will have a greater change in momentum due to the conservation of momentum.

- The greater the change in momentum that the balls undergo, the greater the force on them must be (greater impulse). By Newton's Third Law, we can also say that this relatively large force from the ball exerts a relatively large force on the block, and vice-versa.

Setup instructions

1. Make sure that the chem stand is set up with the crossbar and upright pole forming a "t".
2. Tie the happy and sad balls attached to strings to the crossbar one on either side of the upright.
3. Ensure that both balls are tied to hang at the same height, just below the top of the blocks. Place the sad ball with the frowning (sad) block and the happy ball with the smiling (happy) block.
4. Make sure that the blocks' faces are towards your audience.



Instructional Procedure

1. Start off by asking the students which has more force involved: sticking or bouncing.
2. Use the two unstrung balls to explain the difference between happy and sad balls (below). Then, ask them which ball they would expect to make the block fall over.
3. After they make their predictions, lift the balls high enough such that when they hit, the happy one knocks over the board and the sad one

does not.
4. Repeat a couple of times (if needed) and explain.

Tips & Tricks

- Practice a few times to know the appropriate height to drop the balls from. Too high or too low will not give the correct outcome and may confuse the students.

Assessment Questions

- Why does one block fall over and one stay up?
    - A: Due to Newton's Third Law, the happy ball has to undergo a greater change in momentum, which transfers to the block and knocks it over.
- Can you think of any other materials that bounce or don't bounce when they hit something?
    - A: Bounce: rubber or polymers
    - A: Don't bounce: yarn, cloth, rocks

Clean Up

- Be sure to disassemble the stand and gather all four of the balls.

References

- Conservation of Linear Momentum, Happy-Sad Ball Website, Impulse

Related Next Generation Science Standards

- K-5
    - K-PS2 Motion and Stability: Forces and Interactions
    - 3-PS2 Motion and Stability: Forces and Interactions
    - 4-PS3 Energy
- 6-8
    - MS-PS2 Motion and Stability: Forces and Interactions
- 9-12
    - HS-PS2 Motion and Stability: Forces and Interactions