Kinematic Carts Lesson Plan

Amount of time Demo takes: (3-5 min)

Try this in the classroom!

Lesson's Big Ideas

- Students will study Newton's three Laws of Motion
  - **1st Law**: A body in motion stays in motion unless something else acts on it. A body at rest stays at rest.
  - **2nd Law**: Force is equal to mass times acceleration.
  - **3rd Law**: For every action there is an equal and opposite reaction.
- Newton's Force Equation from Second Law of Motion will be studied and analyzed when the ball thrown pushes the person on the cart backwards.
- Students will be able to witness action and reaction forces, proving Newton's Third Law of Motion.

Materials

- 2 Physics kinematic carts or Gym Scooters (Arbor Scientific Human Dynamics Carts)
- Medicine ball (heavy ball)
- Basketball

SAFETY!

- Physics gliders may only be used while participant is seated, not as a skateboard!
- Watch for fingers and toes to make sure no one gets run over.
- Keep the speed of the gliders to a minimum to ensure the safety of the participants.

Background Information

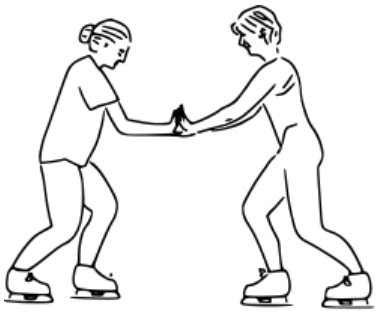
- **Newton's laws of motion** describe the relationship between the forces acting on a body and its motion due to those forces. They are summarized as follows:

1. **First law**: The velocity of a body remains constant unless the body is acted upon by an external force.
2. **Second law**: The acceleration **a** of a body is parallel and directly proportional to the net force **F** and inversely proportional to the mass *m*, i.e., **F** = *m***a**.
3. **Third law**: The mutual forces of action and reaction between two bodies are equal, opposite and collinear.

- The law of **conservation of linear momentum** states if no external force acts on a closed system of objects, the momentum of the closed system remains constant. Momentum is a property of mass and velocity, so larger objects moving quickly have much more momentum than small ones moving slowly. In collisions (such as when one person pushes on the other) the sum of the momenta before the collision must equal the sum of the momenta after the collision:

$$m_1\mathbf{u}_1 + m_2\mathbf{u}_2 = m_1\mathbf{v}_1 + m_2\mathbf{v}_2\,,$$

  where $\mathbf{u}_1$ and $\mathbf{u}_2$ are the velocities before collision, and $\mathbf{v}_1$ and $\mathbf{v}_2$ are the velocities after collision.
- **Science of hockey**: Due to reduced friction from the hockey skate on the ice, you are able to witness Newton's laws in action easier. Sometimes players hit each other and both continue sliding in one direction. You can also see this during shoving matches/fights - both players move backwards during contact, not just the one receiving the hit. This is due to the conservation of momentum and the type of collision (inelastic vs elastic).



Setup Instructions

1. Find a hard, flat, smooth surface to roll carts on. Carpet will not work the carts.
2. Set carts 1-2 meters apart with plenty space in front and behind the carts for them to maneuver.

Instructional Procedure

1. Have participants sit on the carts and have them predict what will happen when they push off each other. What will happen if just one person

pushes off the other? Let them try each to see if they were correct.
2. Have participants predict what will happen when they throw each of the balls to each other, then have them do so.
3. Explain the concepts behind the physics gliders.

Assessment Questions

1. Whose laws are at work?
    a. Newton's Laws of Motion are at work!
2. What are each of Newton's Laws of Motion?
    a. **An object at rest stays at rest and an object in motion stays in motion** with the same speed and in the same direction unless acted upon by an unbalanced force.
    b. The **more force** is directly proportional to **more acceleration**
    c. **In every action there is an equal and opposite reaction** in terms of force.
3. What would be different if two people sat on one cart, and only one on the other?
    a. The heavier cart will not move backwards as much as the lighter cart.

Careers & Real-World Applications

- **Mechanical Engineers** study forces that are exerted on everyday objects like cars. They can make cars more safe with seatbelts and airbags that stop drivers and passengers from moving forward.
- **Physicists** study the world and the laws of energy, time, and space.
- **Aerospace Engineers** develop planes that use air resistance and gravity to keep planes in the air.

Clean Up

- Pack up the carts, make sure the medicine ball and the basketball are back in place.

References

- http://www.youtube.com/watch?feature=player_embedded&v=hU-P-WZ5IYU#!
- http://en.wikipedia.org/wiki/Momentum#Conservation_of_linear_momentum
- http://en.wikipedia.org/wiki/Newton%27s_laws

Next Generation Science Standards

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