Episode 4: Forces in Motion: Ebikes

8th Grade Science Lesson

Summary

In this lesson, students will explore the founda onal principles of forces and mo on through real-world applica ons and a focus on innova ve technology—electric bikes. They will analyze gravita onal, electric, and magne c forces, learn about fric on and drag, and understand balanced and unbalanced forces. By incorpora ng insights from Paul Perkins, CEO of Orion Electronics Company, students will see how these concepts are applied in crea ng lightweight, sustainable ebikes, emphasizing problem-driven innova on and sustainability.

Objective:

- Differentiate between gravitational, electric, and magnetic fields.
- Explain the effects of balanced and unbalanced forces on motion.
- Create and interpret force diagrams.
- Investigate friction and drag through experimentation.

Key Concepts:

1. Gravitational fields and their relationship to mass and distance.
2. Electric fields and their role in attracting or repelling charges.
3. Magnetic fields and their influence on magnetic objects.
4. Balanced vs. unbalanced forces and their effects on motion.
5. Friction and drag as forces opposing motion.

Key Vocabulary:

- **Gravitational Field** – The region of space around a mass where gravitational forces act on other masses.
- **Force Diagram** – A visual representation showing the direction and magnitude of all forces acting on an object.
- **Kinetic Friction** – A force opposing motion between two sliding surfaces.
- **Drag** – A resistive force acting on an object moving through a fluid, such as air or water.
- **Net Force** – The overall force acting on an object when all individual forces are combined.

Pre-Video Discussion Questions:

1. **What is a force? Can you name some examples in your daily life?**

   Discussion Point: Examples include gravity pulling objects down, magnets attracting metals, or friction slowing objects.

2. **Have you noticed how objects can slide differently on smooth vs. rough surfaces? Why do you think this happens?**

   Discussion Point: Friction changes depending on surface texture and material.

3. **What happens if you push a toy car and stop applying force? Will it keep moving? Why or why not?**

   Discussion Point: Friction and drag slow objects unless another force counteracts them.

4. **What forces impact the motion of a bicycle?**

   Discuss examples like pedaling force, gravity, and friction.

5. **Why might reducing a bike's weight improve its performance?**

   Discuss how weight is related to gravitational force and inertia.

Activity:

Materials Needed:

- Toy cars or small models.
- Ramps of various inclines.
- Small weights or washers (to simulate added load).
- Smooth boards and sandpaper for friction comparison.
- Fans or hairdryers (to simulate drag).
- Printable force diagram templates (arrows and labels for students to use).
- Magnets and iron objects (for magnetic force exploration).

Procedure

1. Gravitational Force Experiment:
    - Place toy cars on ramps of varying inclines.
    - Release the cars and measure how far and fast they travel.
    - Discuss how incline impacts gravitational pull and acceleration, relating to how e-bikes assist riders uphill.
    - Add small weights to the cars to simulate heavier e-bikes, observing how added mass affects their motion.
2. Friction Test:
    - Test car movement on smooth boards vs. sandpaper.
    - Measure how far the cars travel on each surface.
    - Relate findings to how rugged or tubeless tires impact e-bike friction and performance on different terrains.
3. Drag Simulation:
    - Use fans or hairdryers to blow air against the moving cars to simulate drag.
    - Discuss how streamlined designs can reduce drag and improve efficiency, as seen in Orion's lightweight frames.
4. Magnetic Fields Exploration:
    - Place magnets on either side of a toy car and move them closer or farther to simulate attraction and repulsion forces.
    - Discuss how similar principles are used in electric motors and energy transfer systems in e-bikes.
5. Force Diagram Creation:
    - Provide templates for students to label forces acting on their toy car models during each experiment (e.g., gravitational pull, friction, drag, applied force).

- Compare these diagrams to real-world e-bike scenarios, highlighting balanced and unbalanced forces.

Discussion and Analysis

- **Data Analysis:**
  Students compare speeds, distances, and observations across different experiments.
  - How do incline and weight affect the motion?
  - Which surface produced the most resistance, and why?
  - How did simulated drag impact movement, and what design adjustments could counteract it?
- **Connecting to E-Bikes:**
  - Why are lightweight frames and optimized tires essential for e-bike efficiency?
  - How do e-bike pedal-assist systems reduce the impact of gravitational and frictional forces?
  - Relate the experiments to Paul Perkins' insights on innovative and sustainable transportation solutions.

Extensions:

1. **Design Challenge:**
   Students design an improved e-bike model using their knowledge of forces, materials, and sustainability. Include sketches and descriptions of features to reduce drag and friction while maintaining efficiency.
2. **Community Connection:**
   Research how e-bikes are being used locally for transportation and brainstorm ideas to encourage their adoption.

Post-Video Discussion Questions:

1. **How does reducing the weight of an ebike impact the forces acting on it?**

   Answer: Less gravity pulling down on the object and therefore less friction between the road and the tires.

2. **Why is pedal-assist technology important in overcoming forces like gravity?**

   Answer: It helps the rider not have to expend as much energy when going up hills.

3. **Based on Paul Perkins' vision, how might ebikes change transportation in the future?**

Answer: They will make transportation more accessible. For instance, people can pay monthly to have unlimited access to shared community bikes.

4. **How do gravitational, electric, and magnetic fields differ in how they act on objects?**

   Answer: Gravitational fields depend on mass, electric fields depend on charge, and magnetic fields depend on magnetic poles.

5. **What happens to the motion of an object when forces are balanced?**

   Answer: The object remains stationary or moves at a constant speed.

6. **How does friction affect an object's motion?**

   Answer: Friction opposes motion, causing objects to slow down or stop unless another force is applied.

7. **Why is it important to consider drag when designing vehicles?**

   Answer: Drag impacts speed and efficiency, so minimizing it improves performance and energy use.