Newton's 2nd Law
4th Grade

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Benchmarks:

SLC 12: A.) Students will apply concepts of Newton's Laws in scientific explorations. B.) Students will explore the relationships among force, mass, direction and speed on moving objects.

Objectives:

To help students test and identify the characteristics of objects that makes them easier or harder to push, in the process discovering Newton's 2nd Law: heavy objects are harder to push than light objects.

Materials:

- Beach balls
- Foam balls
- Baseballs
- Shot put balls
- Rubber bands
- Metric rulers
- String
- Tape
- Graph paper

Initial Model (from *Newton's 1st Law* lesson):

-A force is a pushing or pulling of another object.
-When the forces on an object are balanced the object doesn't move.
-When an object rubs or rolls against another object, the friction force slows the moving object down.

-Friction is different for different surfaces. Rough surfaces like sandpaper have more friction, while smooth surfaces like a table have less friction, because sandpaper has lots of bumps but a table does not.

-Newton's 1st Law: Objects at rest stay at rest and objects in motion stay in motion unless acted on by a force.
-Newton's 3rd Law: When something is pushed or pulled, even if it doesn't move, it pushes or pulls back.

Initial Demonstration:

Do all objects require the same amount of force start them moving (as required by Newton's 1st Law)? Give me some examples. What types of objects are the hardest to move? Do you think the size matters?

Target Observations:

- A paper clip is easier to move than a table
- A piece of paper is easier to move than a brick
- Large and heavy objects are harder to move than small and light objects.

Target Model:

-A force is a pushing or pulling of another object.
-When the forces on an object are balanced the object doesn't move.
-When an object rubs or rolls against another object, the friction force slows the moving object down.

-Friction is different for different surfaces. Rough surfaces like sandpaper have more friction, while smooth surfaces like a table have less friction, because sandpaper has lots of bumps but a table does not.

-Newton's 1st Law: Objects at rest stay at rest and objects in motion stay in motion unless acted on by a force.
-Newton's 3rd Law: When something is pushed or pulled, even if it doesn't move, it pushes or pulls back.
-*Large objects are harder than small objects to move because they are larger.*
-*Heavy objects are harder than light objects to move because they are heavier.*

Procedure:

How can we test the idea that large objects are harder to move than small objects? Split the class up into groups of 2-3 students. In groups, students should think of some way that they can test the idea that large objects are harder to move than small objects. What do your experiments say about our guess that large objects are harder to move?

Target Experiments:

1. Students control as many variables as they can by finding two or more spherical objects about the same weight but different sizes (i.e. a beach ball and a foam ball). One student holds a rubber band between their fingers, pulls it back a measured amount, then releases, striking the ball with a standard amount of force. Another student measures the distance the ball rolls after being struck (why did it stop?). This is done for both balls. Students perform the experiment multiple times on the same surface, preferably a smooth one to minimize the amount of friction. Students graph the data on a bar graph where the objects are sorted from lightest to heaviest on the x-axis, and the distance they traveled as the height of the bar.
2. Students find two or more objects about the same weight but different sizes (i.e. a beach ball and a foam ball, or a block eraser and a stack of coins). The objects are hung by string over the edge of a table so that they can swing freely. One student holds a rubber band between their fingers, pulls it back a measured amount, then releases, striking the object with a standard amount of force. Another student measures the distance the object swings after being struck (why did it stop?). This is done for both objects. Students perform the experiment multiple times with as little wind in the room as possible to minimize air resistance. Students graph the data on a bar graph where the objects are sorted from lightest to heaviest on the x-axis, and the distance they traveled as the height of the bar.

Target Observations:

- The objects/balls are about the same weight.
- Both objects/balls went the same distance.

Target Revised Model:
-A force is a pushing or pulling of another object.
-When the forces on an object are balanced the object doesn't move.
-When an object rubs or rolls against another object, the friction force slows the moving object down.

-Friction is different for different surfaces. Rough surfaces like sandpaper have more friction, while smooth surfaces like a table have less friction, because sandpaper has lots of bumps but a table does not.

-Newton's 1st Law: Objects at rest stay at rest and objects in motion stay in motion unless acted on by a force.
-Newton's 3rd Law: When something is pushed or pulled, even if it doesn't move, it pushes or pulls back.
~~-Large objects are harder than small objects to move because they are larger.~~
-Heavy objects are harder than light objects to move because they are heavier.

Procedure:

Now that we have found out that size doesn't seem to matter too much in how easy it is to move an object, how can we test the idea that heavy objects are harder than light objects to move? Once again, work in your groups to devise a test.

Target Experiments:

1. Students find two or more balls that are the same size but different weights (i.e. baseball and shot put). One student holds a rubber band between their fingers, pulls it back a measured amount, then releases, striking the ball with a standard amount of force. Another student measures the distance the ball rolls after being struck (why did it stop?). This is done for both balls. Students perform the experiment multiple times on the same surface, preferably a smooth one to minimize the amount of friction. Students graph the data on a bar graph where the objects are sorted from lightest to heaviest on the x-axis, and the distance they traveled as the height of the bar.
2. Students find two or more objects that are the same size but different weights (i.e. baseball and shot put or plastic egg filled with air or rocks). The objects are hung by string over the edge of a table so that they can swing freely. One student holds a rubber band between their fingers, pulls it back a measured amount, then releases, striking the object with a standard amount of force. Another student measures the distance the object swings after being struck (why did it stop?). This is done for both objects. Students perform the experiment multiple times with as little wind in the room as possible to minimize air resistance. Students graph the data on a bar graph where the objects are sorted from lightest to heaviest on the x-axis, and the distance they traveled as the height of the bar.

Target Observations:

- The two balls/objects are about the same size but different weights
- The heavy ball/object went further than the light ball/object

Target Revised Model:

-A force is a pushing or pulling of another object.
-When the forces on an object are balanced the object doesn't move.
-When an object rubs or rolls against another object, the friction force slows the moving object down.

-Friction is different for different surfaces. Rough surfaces like sandpaper have more friction, while smooth surfaces like a table have less friction, because sandpaper has lots of bumps but a table does not.

-Newton's 1st Law: Objects at rest stay at rest and objects in motion stay in motion unless acted on by a force.
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-Heavy objects are harder than light objects to move because they are heavier.

Procedure:

How could we improve our experiments to make them better? Is there a better way to display our data? Could we have taken more measurements? We have just discovered Newton's 2nd Law: heavy objects are harder to push than light objects.

Target Responses:

- We could have placed all of the objects on ice to reduce the effects of friction
- We could have used a better way of pushing the objects (roll them down something?)
- We could have taken measurements of the weight of the objects to see if they were the same/different

Target Revised Model:

-A force is a pushing or pulling of another object.
-When something is pushed, even if it doesn't move, it pushes you back.
-When the forces on an object are balanced the object doesn't move.
-When an object rubs or rolls against another object, the friction force slows the moving object down.

-Friction is different for different surfaces. Rough surfaces like sandpaper have more friction, while smooth surfaces like a table have less friction, because sandpaper has lots of bumps but a table does not.

-Newton's 1st Law: Objects at rest stay at rest and objects in motion stay in motion unless acted on by a force.
-*Newton's 2nd Law: heavy objects are harder to push than light objects.*
-Newton's 3rd Law: When something is pushed or pulled, even if it doesn't move, it pushes or pulls back.