Laws of Motion

STARFINDER

PROGRAM 5

Instructional Objectives

After viewing the program and participating in the accompanying activities, the student will be able to:

1. explain Newton's Laws of Motion,
2. demonstrate the introduction of forces which impede motion, and
3. compare and contrast the motion of binary stars with the motion of those stars traveling through space unimpeded by the immediate attraction of other celestial bodies.

Synopsis

"Science Links" uses a fast-paced air hockey game as a lead-in demonstration to Newton's First Law of Motion. Other familiar earth-bound objects demonstrate the role of air resistance, friction, and gravity in motion. The concept is transferred to stars traveling through space. Unhindered by resistance, most stars would move in one general direction. Animation shows one major exception to such stellar movement — the paths of binary stars, whose constant movements are changed towards one another's gravitational fields.

The role of the Space Telescope Science Institute's computer illustrator/animator is highlighted in "The People Behind the HST." The students are shown many aspects of the artist whose posters, animation, and graphics are used by the Science Institute to explain and communicate its work with other scientists and with the general public.

Vocabulary

Animation Sequence - Motion video made from a series of computer graphic images that simulate specific objects or processes over time.

Binary Stars - Two stars that orbit about their common center of mass and are held together by their mutual gravitational attraction.

Constant - The element in an experiment that does not change.

Inertia - An object's tendency to resist change in motion; to stay as it is, either at rest or in motion.

Force - Any push or pull with strength and direction.

Friction - The rubbing together of two substances; hindrance to motion.

Moving Cluster or Star Cluster - A group of stars formed at almost the same time and place. They may remain as a unit for billions of years because of their mutual gravitational attractions.

Resistance - Any force that hinders motion.

Variable - The factor that changes or varies in an experiment.

Velocity - Rate of motion; speed with direction.

Previewing

Discuss vocabulary terms.

Roll a baseball, or similar object, across the floor. Place a second ball on a desk. Ask students which ball is in its "natural state." Discuss why.

Sprinkle iron filings on a paper that is covering a bar magnet. Compare magnetic fields with gravitational fields.

Place a quarter on a strip of paper. Pull the paper with a rapid, sudden movement. Discuss.

Postviewing

Discuss the latest information received from the Hubble Space Telescope. Discuss the interaction of art and science in the career of Dana Berry, computer illustrator/animator at the Space Telescope Science Institute.

Repeat baseball activity. Ask students again which ball is in its "natural state." Have their answers changed? Why?

Active Involvement

If possible, bring into class a small air hockey game.

Propel objects across a variety of surface textures such as tile, sandpaper, or carpet, and record the distances traveled. Chart the results. Then propel a variety of objects, such as a stone, a block of wood, an ice cube and an eraser across a table. Chart the results.

Set up a stack of checkers. Have students predict what would happen to the stack if they were to shoot another checker at the bottom checker. Now have a student shoot the loose checker directly at the bottom of the pile. (The bottom checker should fly out from the stack and the rest of the stack should drop down to the table top.) Discuss this experiment in terms of inertia.

Have a student inflate a balloon and then let go of the end. Discuss the action/reaction effect in terms of Newton's Third Law of Motion.

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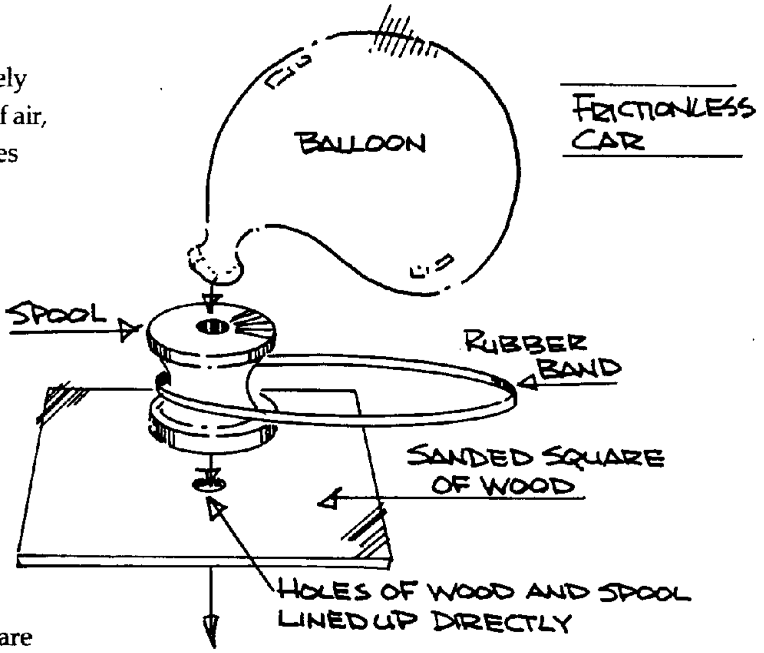
See for Yourself: Experiments/Projects

STARFINDER

PROGRAM 5

Making a Frictionless Air Car

According to Newton's First Law of Motion, the less friction a moving object encounters, the farther it is likely to travel. You can build a car that moves on a cushion of air, much like the puck in a game of air hockey. This car uses the same principles as a hovercraft.



▶MATERIALS:

- a 2 1/2" - 3" disc or square of thin wood or heavy cardboard with small hole (about 1/16") in center
- sandpaper
- empty spool
- balloon
- small rubber band

▶DIRECTIONS:

1. Sand the bottom and edges of the wood disc or square until very smooth. Round off the corners if using a square.
2. Attach the spool to the wood so that the hole of the spool is directly over the hole on the wood. Let glue set.
3. Place rubber band over spool.
4. Inflate balloon and carefully slip over the rim of the spool. You will need to pinch off the neck of the balloon while connecting it to the spool (see diagram). Secure balloon with rubber band.
5. Release car and give a flick so that the car will move across the table or floor with almost no friction. Measure and record distance.
6. Try propelling the car without the help of the inflated balloon. Record the distance.
7. Predict what the distance would be if you used a larger balloon. Write down your predictions. Now try the larger balloon and compare the actual distance with your prediction.
8. Predict what the distance would be if the car was traveling over carpeting or grass. Write down your prediction. Now try moving the car over carpeting, grass, or other substances. Compare your prediction with the actual distance.

Demonstrating Newton's Second Law of Motion with a Cork Accelerometer

Newton's Second Law of Motion explains the relationship between amount of matter, MASS (m), and how that mass increases speed or ACCELERATES (a), when it is pushed or pulled, FORCE (F). The equation representing this is "force = mass times acceleration" or F = ma. In other words, if the mass is small, little force is needed to change its speed, but if it is large, greater force is needed.

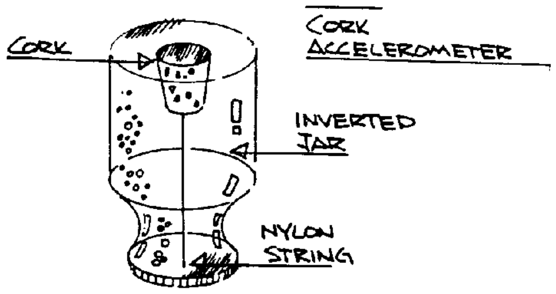
A simple cork accelerometer indicates the direction of acceleration.

▶MATERIALS:

- glass jar or erlenmeyer flask
- cork
- nylon string
- waterproof tape

▶DIRECTIONS:

Attach cork to jar lid with string and tape. Fill jar with water, screw on lid tightly and invert jar, so that the cork just floats to the surface (see diagram). When there is no acceleration, the cork will float straight up, but when the accelerometer is in motion, the cork will point towards the direction of acceleration. This device can be used to observe the direction and size of acceleration.



Studying Force, Mass, and Acceleration

This experiment makes use of constants and variables within an experimental setting.

▶MATERIALS:

- two heavy duty rubber bands
- small wagon
- weights or heavy books to fit in wagon

▶DIRECTIONS:

Part I: Find out how much force is needed to move a heavy wagon when the mass is constant and acceleration is zero.

Attach one rubber band to the front of the wagon. Place enough books or weights in the wagon to require significant pull on the rubber band to get the wagon to move.

1. Measure the length of the rubber band when extended but not stretched (measurement 1 in diagram). Record measurement.
2. Pull on the rubber band just until the wagon begins to move. Measure the length of the stretched rubber band (measurement 2 in diagram). Record measurement.
3. Subtract measurement 1 from measurement 2. Record. The distance between the two measurements is the amount of force needed to move the wagon.

Part II. Observe a change in acceleration while force and mass are constant. Attach the accelerometer to the wagon. Pull hard enough on the rubber band to move the wagon and keep the band stretched at a constant length.

1. Watch what happens to the accelerometer. Write down your observations.

Part III. Double the force and see what happens to acceleration.

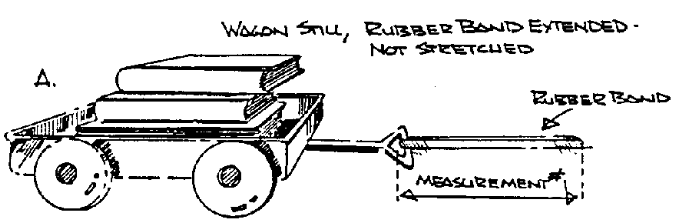
To change the variable of force, attach a second rubber band to the front of the wagon. Pull hard enough to stretch the two bands the same amount as the one rubber band had been stretched before.

1. Watch to see what happens to the accelerometer when the force is doubled. Record your observations.

Part IV. Change the mass. Will you need the same amount of force?

1. Try adding weight in the wagon. Observe and record the same information as you did in Part I. What has changed? Write down your observations.
2. Remove weights from the wagon. Observe and record the same information as you did in Part I. Record your observations.

A.



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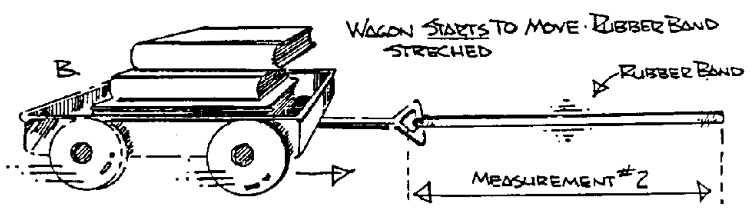

Science Career Profile

STARFINDER
PROGRAM 5

DANA BERRY
Computer Animator/Illustrator
Space Telescope Science Institute
Education: B.A. Fine Arts
M.F.A. Film Production, animation emphasis

Chief Responsibilities

As the chief illustrator and animator for the Space Telescope Science Institute, Dana Berry serves as the animation producer and art director for public affairs. It is Dana's responsibility to make sure that the art projects at the Science Institute are completed in time, with a high degree of quality, and within the budget.

Most of Dana's work is created to assist astronomers who need visual presentations when working with other scientists or speaking to the public. This artwork might take the form of a poster, an illustration, or an animated video sequence. His animation and art work are used nationally and internationally on television, in magazines and newspapers, and in personal presentations by scientists.

Dana is also responsible for keeping his equipment in working order. When there is a problem, he must decide whether to fix a piece of equipment or to replace it.

About once a week, Dana gives presentations to visitors at the Science Institute. People are always interested, not only in what he is producing, but in how he does his art.

It is important that Dana maintain contact with scientists through every step of the art process. Everything he produces must be scientifically accurate.

A Typical Day

Like many people in the art field, Dana has a schedule that changes from day to day. A typical day might go like this:

In the morning, he may get ready to create a new animation sequence. First he has to build a computer model by entering data points into the computer. After choreographing, or designing the movement, of the models in the animation, he creates sample images for the whole animation sequence. Doing this allows him to check out the accuracy of the sequence and the lighting on the screen. At this point, he may only need to make some small adjustments. At other times, he might need to completely change his strategy and go back to the beginning and start over.

In the afternoon, Dana may go over to his art studio and work on a poster. He puts many hours into the planning of one poster, checking it carefully with science experts to make sure that what he has designed is accurate. After all changes are made and he is satisfied with the art and science, the poster will go to the printer. Dana often works with the printer during the printing process so that every part of the poster comes out just as he designed it.

Even after work, Dana likes to do artwork and create things. He enjoys building robots and models. He likes to think he is still a "kid at heart."

Career Viewpoint

Dana is in a unique position to mix art and science. He feels his art career at the Space Telescope Science Institute offers him the opportunity to be a translator or interpreter of science.

He enjoys the freedom to be creative and likes to expand his skills as an artist. But it is his awareness of many other subjects, such as math, science and art history, that has given him the power and knowledge to make creative decisions within his job.

Content Consultants for STARFINDER – Program 5

Eric Chaisson
Space Telescope Science Institute

Eric Flescher
Shawnee Mission West High School
Shawnee Mission, Kansas

Ed Griffin
Glen Burnie High School
Glen Burnie, Maryland

Anita Stockton
Baltimore County Public Schools
Towson, Maryland

Teacher's Guide

Writers
Barbara Bourne
Patricia Murphy

Editor
Kate Harrison

Illustrator
Dave Weaver

Graphic Design
Bob Lindler
The Design Co-op

Typesetting
Blue Heron Typesetters