PHYSICAL FORCES: GET MOVING!

A LEGOLAND® California
Educational Resource Guide
Grades 2-4

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Welcome to LEGOLAND California

Education Programs: "Physical Forces: Get Moving!" was developed by the LEGOLAND Education Department in cooperation with LEGO Education. For information on LEGOLAND Education programs, visit www.LEGOLAND.com/edu**.**

Extended Learning in the Park: Lab Notes are provided to guide your experience through recommended rides and attractions, to enhance the Physical Forces-themed educational experience and provide applied learning.

Arrival and Entry: Please arrive 30 minutes before your program. Teachers must be present during the staff-facilitated 45-minute program.

Lunches: Lunches may be pre-ordered when you book your program, or purchased at LEGOLAND restaurants. School groups may bring lunches in disposable containers and use self-storage bins.

Safety: LEGOLAND Parks are built to the highest standards of quality and safety. Height restrictions apply on selected attractions throughout the Park.

Background Information

What is Force?

Force is any push or pull. Force is needed to provide motion, change direction or speed, and to stop.

Forces cause objects to move.

Gravity constantly pulls all things toward the center of the earth. TECHNIC® Coaster is gravity-powered.

Inertia makes an object resist a change of motion.
When the TECHNIC Coaster speeds up, riders feel pinned to the back of the car. Inertia makes it a fun ride!

Riders also experience inertia when the car stops and they feel "pushed" forward against the lap bar. Inertia makes your body want to continue moving as it had been moving.

When inertia is at work, an object at rest tends to stay at rest, and an object in motion tends to stay in motion.

Centrifugal Force pulls objects away from the center of motion. AQUAZONE® riders hang on as centrifugal force pulls them to the side of the car, away from the center of the ride.

Wind resistance pushes against the vehicle to slow it down. Riders on many different rides can feel wind resistance as their hair blows backwards. Cars that are low and sleek face less wind resistance.

What forces act on a car going down a slope?

Friction is the amount of surface contact between a car and the slope: Less friction, faster car.
Friction can cause heat when two surfaces come in contact and rub together.

How do we reduce friction to make a car go faster?

- **Change the slope's surface.** The smoother the surface, the faster the car.
- **Change the slope's angle**. The steeper the slope, the faster the car.
- **Change the tires**. Usually the car will go faster with narrow and smooth tires.

Weight can also make a car go faster or slower. In theory, a heavy and lightweight object released at the same time from the same point on a ramp should reach the bottom at the same time.

In reality, a light object often travels faster, but not as far. A heavy object often travels slower, but farther. This is due to different amounts of friction in the wheels and axles.

Hands-On Activities

Get Moving in the Imagination Zone!

Plan Your Design

Think about forces that would make your car go faster or slower.
What design might make the fastest car?

Build and Test!

Work in pairs to build a fast car. Test your car on the Maniac Midway speed ramps.
Use sensors to test the car's performance. Redesign and test your vehicles until you are ready to race.

Race on the Maniac Midway!

Race the cars on the speed ramp in heats until all cars have raced.
Which car went the fastest? Look at the design of the car. Why do you think it was the fastest?

Discovery and Learning at LEGOLAND

How do forces act on these rides?

Think about inertia, centrifugal force, gravity, friction, and wind resistance.

Kid Power Towers

Riders pull the cable to go up, then slowly come down when they let go of the cable.

What force helps riders go down?

_____

BIONICLE® Blaster spins in a circle. Which force pushes riders away from the center? (Hint, see p. 2)

_____

TECHNIC Coaster speeds up suddenly. Which force makes riders feel pinned back, as if they haven't started moving?

_____

AQUAZONE riders feel air pushing against them. Which force is at work?

_____

Before and After the Visit Activities

Make your own Maniac Midway!

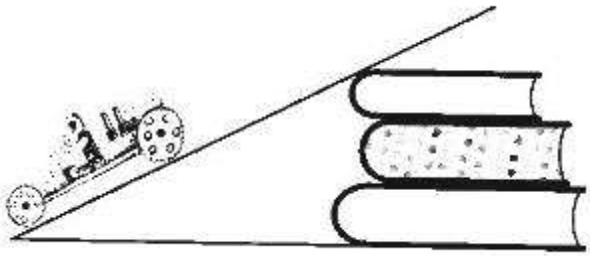
Set up a ramp in your classroom and test the effects of forces acting on the cars you race.

Materials and Set up

Cardboard or plank propped at an angle with books.
Toy cars or LEGO® cars
Carpet runner, to place on ramp
Weights for cars (Coins will work.)
Tape measure to measure the distance traveled
Bar graph to record distance traveled under different conditions

See the changes when different forces are at work.

Change only one factor at a time to see how the car's performance changes under different conditions.
Use the same car for each trial.



Trial #1

Release a car from the top of the ramp. Record the distance traveled from the bottom of the ramp.

Trial #2

Put a carpet runner on top of the ramp. This will increase friction. Now release a car from the top of the ramp.
Did the car travel slower or faster? Did it go farther or not as far?

Trial #3

Take the runner off the ramp. Tape a weight to the car. Release it from the top of the ramp.
Did it affect the car's performance?

Trial #4

Take the weight off the car. Add books to the ramp to make it steeper. Release a car from the top of the ramp.
Did the car go faster or farther?
Now take books off the ramp to make it less steep. How does the car perform?

About Physical Forces

Learning Outcomes

- Learn about forces, such as gravity, friction, and inertia.
- Build a vehicle. Redesign and measure the change in performance.
- Evaluate the design of the winner and offer an explanation for why it won.
- Relate concepts to the experience of LEGOLAND attractions.

California Next Generation Science Standards

K-2 Engineering Design

K-2-ETS1-1. …Define a simple problem that can be solved through development of a new or improved object or tool.
K-2-ETS1-2. Develop a simple…physical model to illustrate how the shape …helps it function to solve a given problem.
K-2-ETS1-3. (T)est two objects designed to solve the same problem to compare strengths and weaknesses of each….

K-2 Matter and Its Interactions

2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. [Clarification Statement: Examples of pieces could include…building bricks…]

GRADE 3-5 Motion and Stability: Forces and Interactions

3-PS2-1. Plan and conduct an investigation to provide evidence of…forces on the motion of an object
3-PS2-2. (O)bserve or measure an object's motion to provide evidence that a pattern can be used to predict future motion.

GRADE 3-5 Engineering Design

3-5-ETS1-1. Define a simple design problem…that includes criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2. Generate and compare multiple possible solutions…based on how well each is likely to meet the criteria….
3-5-ETS1-3. Plan and carry out fair tests…to identify aspects of a model or prototype that can be improved.

The performance expectations above were developed using NRC Framework for K-12 Science Education:

Science and Engineering Practices

Asking Questions and Defining Problems

- Ask Q's based on observations to find…info about the designed world. (K-2-ETS1-1) & based on patterns such as cause and effect (3-PS2-3)
- Define a simple problem that can be solved thru development of a new/improved object…(K-2-ETS1-1) (3-PS2-4) & includes…criteria for success….(3-5-ETS1-1)

Developing and Using Models… based on evidence to represent a proposed object or tool. (K-2-ETS1-2)
Analyzing and Interpret Data from tests of an object…to determine if it works as intended. (K-2-ETS1-3)
Planning and Carrying Out Investigations …to…test a design solution. (3-PS2-2)
Construct Explanations and Design Solutions Generate & compare solutions…based on how well they meet criteria….(3-5-ETS1-2)

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- A situation people want to change or create can be approached as a problem to be solved through engineering.(K-2-ETS1-1)
- Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1)
- Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)
- …Different…solutions can be compared on the basis of how well each one meets the criteria for success…. (3-5-ETS1-1)

ETS1.B: Develop Possible Solutions

- Designs can be conveyed through…models (and) are useful in communicating…solutions. (K-2-ETS1-2)
- …Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- Communicating with peers about proposed solutions…can lead to improved designs. (3-5-ETS1-2)
- Tests are often designed to identify…difficulties, which suggest elements…that need to be improved. (3-5-ETS1-3)

ETS1.C: Optimizing the Design Solution

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)
- A great variety of objects can be built up from a small set of pieces. (2-PS1-3)
- (Test) different solutions to determine which best solves the problem, given the criteria and constraints. (3-5-ETS1-3)

PS2.A: Forces and Motion

- Each force…has both strength and direction (and) can cause changes in the object's speed or direction of motion. (3-PS2-1)
- Patterns of an object's motion…can be observed and measured; …future motion can be predicted from it (3-PS2-2)

PS2.B: Types of Interactions Objects in contact exert forces on each other. (3-PS2-1)

Crosscutting Concepts

Structure and Function Shape and stability of structures of …designed objects are related to their function(s). (K-2-ETS1-2)
Cause and Effect Events have causes that generate observable patterns. (2-PS1-4).
Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)
Energy and Matter Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-)

Patterns of change can be used to make predictions. (3-PS2-2)
Cause and Effect relationships are routinely identified (3-PS2-1), tested, and used to explain change. (3-PS2-3)

Common Core State Standards Connections K-2 and Grades 3-5

ELA/Literacy –
W.2.8 Recall information from experiences…to answer a question. (K-2-ETS1-1),*(K-2-ETS1-3)*
SL.2.5 Create…visual displays to…recount experiences…to clarify ideas…. *(K-2-ETS1-2)*
SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail. *(3-PS2-3)*
Mathematics –
MP.2 Reason abstractly and quantitatively. *(K-2-ETS1-1),(K-2-ETS1-3) (3-PS2-1)*
MP.5 Use appropriate tools strategically. *(K-2-ETS1-1),(K-2-ETS1-3) (3-PS2-1)*