The Learning Lab:

Zipping Towards STEM Careers

Classroom Connection: Force, Motion, Energy (Physics)

TEKS:
K.1A, K.2A, K.2B, K.2C, K.2D, K.2E, K.3A, K.3B, K.5A, K.6C, K.6D
1.1A, 1.2A, 1.2B, 1.2C, 1.2D, 1.2E, 1.3A, 1.3B, 1.5A, 1.6C
2.1A, 2.2A, 2.2B, 2.2C, 2.2D, 2.2E, 2.3A, 2.3B, 2.5A, 2.5D, 2.6D

3.1A, 3.2A, 3.2B, 3.2C, 3.2D, 3.2E, 3.2F, 3.3A, 3.3B, 3.4A, 3.6B
4.1A, 4.2A, 4.2B, 4.2C, 4.2D, 4.2E, 4.2F, 4.3A, 4.3B, 4.4A, 4.6B
5.1A, 5.2A, 5.2B, 5.2C, 5.2D, 5.2E, 5.2F, 5.2G, 5.3A, 5.3B, 5.4A, 5.6B

6.1A, 6.2A, 6.2B, 6.2D, 6.2E, 6.3A, 6.4A, 6.8A, 6.8C, 6.8B, 6.8D, 6.8E
7.1A, 7.2A, 7.2B, 7.2D, 7.2E, 7.3A, 7.4A, 7.7A
8.1A, 8.2A, 8.2B, 8.2D, 8.2E, 8.3A, 8.4A, 8.6A, 8.6C, 8.7A, 8.8A, 8.8C, 8.8D

Learning Lab Activity: Zip Away/Zippity Doo Dah

STANDARD CLASS TRIP (Groups of 10+ students)	STUDENTS	REQUIRED TEACHERS & CHAPERONES	EXTRA CHAPERONES
MUSEUM EXHIBITS (required)	$6	FREE	$7
3D MOVIE	FREE	FREE	FREE
ADD-ONS			
LEARNING LAB	$4-6	FREE	N/A
BOX LUNCH	$4	$4	$4

ZIPLINE LESSON:

Lesson Objectives: Students will work in teams to discover the correlation between the Engineering Design Process and the Scientific Method. In this lab, students will design and craft a carrier for their zipline, make improvements to their design, and complete challenges to identify their best prototype. Students will actively apply the Engineering Design Process to a fun engineering design challenge while exploring real life applications to concepts such as gravity, friction, force, motion, and slope.

Content Concepts: The zipline activity is a great way to introduce the relevancy of Newton's Laws and basic physics. Students will explore how gravity, friction, inertia, mass, slope and force are related to an object's motion. These key physics concepts help engineers design and create thrilling rides and functional structures. Students will learn how to overcome friction and utilize the effects of gravity to create a safe, yet thrilling zipline ride. While experimenting with the mass of the carrier, students will see how gravity works outside of a vacuum, and observe its effects on heavier and lighter objects. Students will understand how friction, gravity, and mass affect the speed at which an object can travel. Using these experiments to collect pertinent data, they can collect, record, evaluate and compare their data to that of other teams in the classroom. Additionally, students can expand upon this lab to include an entrepreneurial concept, providing real world relevancy. Students will create a company, take into consideration cost of materials and supplies (which will be dictated by the teacher), and evaluate the data collected from the prototype test runs. Then they will develop a business plan explaining the cost analysis for their venture, a business model for their company, a sample budget, and a proof of concept from their testing results to justify their business decisions and overall business endeavor.

Design Challenge:
With your team, use the materials provided and the engineering design process to design two different(and safe!) zipline "cars" for your ping pong ball rider. You do not have to use all the materials, but you may not get any extra supplies!

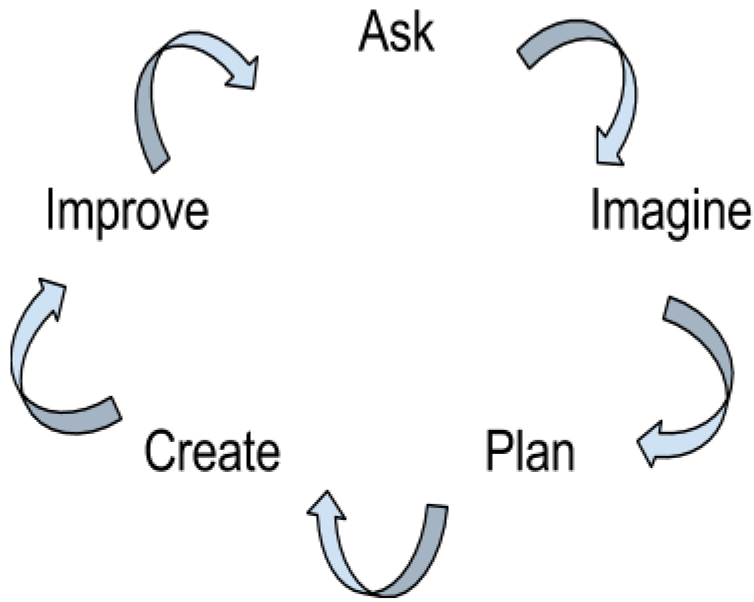
Materials:
3 straws
3 pipe cleaners
2 dixie cups
2 washers
2 half sheets of cardstock
1 milkshake straw
1 launch pad
1 zipline string (2 meters long)
1 ping pong ball
Masking tape

Tools:
Hole Punch
Stop Watch

Challenge Constraints:
- The ping pong ball rider must stay in the carrier for the duration of the ride. It cannot be taped or fixed into the carrier.
- The carrier must travel quickly ($\leq$ 2 seconds)!
- The ride must be fun and SAFE! (If it lands splat on the ground, but the ball doesn't fall out, is it really a safe ride that people would pay to go on?)

Engineering Design Process:

Ask: What questions do you have about the challenge at hand? Ex: What is the problem? What kinds of materials do you have? What are the constraints?



Imagine: What are possible solutions? How can you use your past experiences, prior knowledge, and research to help you come up with a solution? Brainstorm!

Plan: Design your solution - use a diagram, blueprint, or other model. Make a list of materials.

Create: Use your plan to create your solution!

Improve: Take a moment to reflect on your solution - what worked? What could be done better? How can you modify your solution to make a better product?

*Remember to repeat the cycle as you continue to modify your design!

Model:
- Draw a labeled diagram of your zipline car.
- Draw a labeled diagram of your zipline car showing the effects of friction and gravity on your car.
- Draw a labeled diagram of your zipline. Use arrows to label and describe how friction, gravity, mass, weight, and slope affect the speed/acceleration of your car and the force needed to move it down the line.

Challenge extension activities:
- Slow Down! Build a carrier that takes 10 seconds to travel the length of the zip line.
- Increase the Load. Build a carrier that can carry several Ping-Pong balls down the zip line.
- Create a car that launches! How could you make the ride and landing experience both safe and thrilling?

Additional Lesson Plan Ideas/Concepts:
http://pbskids.org/designsquad/build/zip-line/
http://www.nclack.k12.or.us/cms/lib6/OR01000992/Centricity/Domain/98/ED%205%20Performance%20Task-Zip%20Line.pdf
https://www.saddlespace.org/whittakerm/science/cms_page/view/7795329
https://www.saddlespace.org/whittakerm/science/cms_page/view/7795337
http://www.learningscience.org/psc2bmotionforces.htm

LESSON RESOURCES:

Writing Prompts: Sample questions, which can be easily modified to fit your curriculum.
K-2:

- Describe how your zipline car worked.
- How did you design your car? What materials did you use? How do you build your car?

3-5:

- How did you use the engineering design process to create your car design?
- How is the zipline activity related to other feats of engineering such as bridges, skyscrapers or rollercoasters?

6-8:

- Describe how the natural laws of physics affect the function of your zipline car?
- How is the zipline activity related to other feats of engineering such as bridges, skyscrapers or rollercoasters?
- Use the following key terms to describe your experience designing and launching your zipline car.

Key terms:

K-2: Ask, Imagine, Design, Create, Plan, Improve, Engineer, Speed, Fast, Slow, Gravity, Height, Brainstorming, Cause, Effect, Solution, Problem, Heavier, Lighter

3-5: Ask, Imagine, Design, Create, Plan, Improve, Engineer, Speed, Fast, Slow, Gravity, Height, Friction, Brainstorming, Cause, Effect, Solution, Problem

6-8: Ask, Imagine, Design, Create, Plan, Improve, Engineer, Friction, Gravity, Speed, Time, Slope, Distance, Weight, Mass, Force, Acceleration, F=ma, Prototype, Brainstorming, Cause, Effect, Solution, Constraint, Criteria, Problem, Air Resistance, Potential Energy, Kinetic Energy

Vocabulary Connection:
Select 6 words related to the Zipline activity and fill in the blanks in the pie. Write a story or description of how these words relate to what you did during the activity.

____

____

____

____

Sentence STEMs:

K-2:

My car went______________ [up/down] because it was ________________ [heavy/light].

____________[gravity/energy] pulled my car ___________ [up/down] the zipline.

I liked that …

It was challenging to…

We used the engineering design process when…

Next time, I will make my design better by…

3-5:

Adding _____________ to my car made it go ________________ down the line.

___________________ prevented my car from traveling smoothly and quickly down the line.

The engineering design process is…

The most unique part of our design is…

Next time, I will improve my design by…

Friction and gravity played a part in our experiment because…

6-8:

The car had the most ___________ energy at the launch platform.

___________ caused my car to ______________ thereby altering the effects of the natural law of _______________ .

The engineering design process is… because…

My initial prediction/design was… because…

We improved on our design by… and the result was…

We minimized friction by…

Activity Review Questions:

1. The greater the mass of the object, the greater the gravitational pull on that object.

   a. True b. False

2. By adding mass to the carrier, we ______________ the gravitational pull on the carrier.

   a. Decreased b. Increased c. Improved d. Removed

3. ____________ was the force pulling the zipline car down the zipline.

   a. Energy b. Gravity c. Mass d. Friction

4. A force that occurs when an object rubs against another object.

   a. Gravity b. Energy c. Weight d. Friction

5. For every action there is an equal and opposite reaction is Newton's _______ Law of Motion.

   a. Second b. Third c. First d. Only

6. How did the slope of the line affect your car?

   a. Increase slope/faster speed b. Decreased slope/faster speed

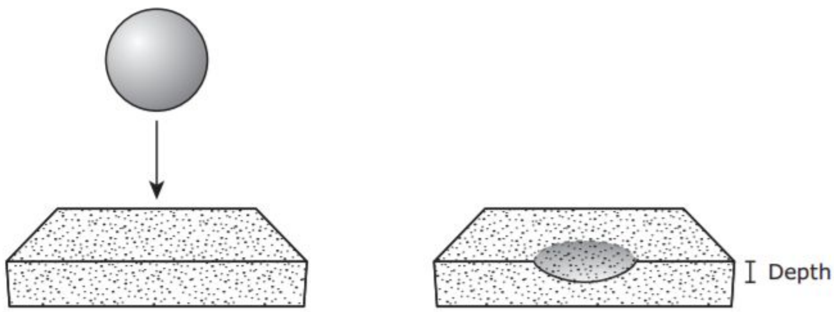
   c. Slope did not affect the car d. Increased slope/slower speed

7. Circle which line would give you the fastest ride. Put a rectangle around the slowest ride.

STAAR Questions:

Grade 5:

39 Students drop the same heavy ball onto identical blocks of soft clay from different heights. For each height they measure the depth of the dent the ball makes in the clay.



Why is the depth of the dent different in each trial?

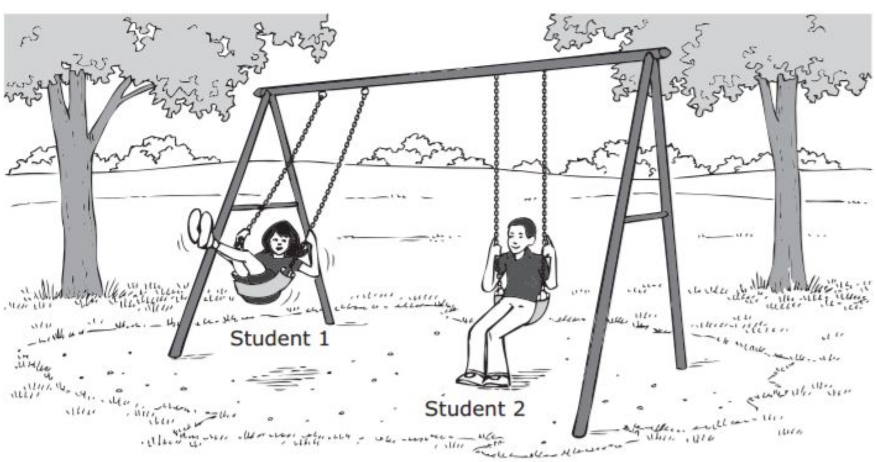
A The size of the ball changes.

B The material of the ball changes.

C The mass of the ball when it hits the clay changes.

D The force of the ball when it hits the clay changes.

15 Two students are playing on a swing set. Student 1 is leaning back and extending her legs as she moves upward. Student 2 is sitting on the swing with his feet on the ground.



Which statement describes how position and work are related in this picture?

A Both students are doing work even if only one student is changing position.

B Student 1 is changing position because work is being done on the swing.

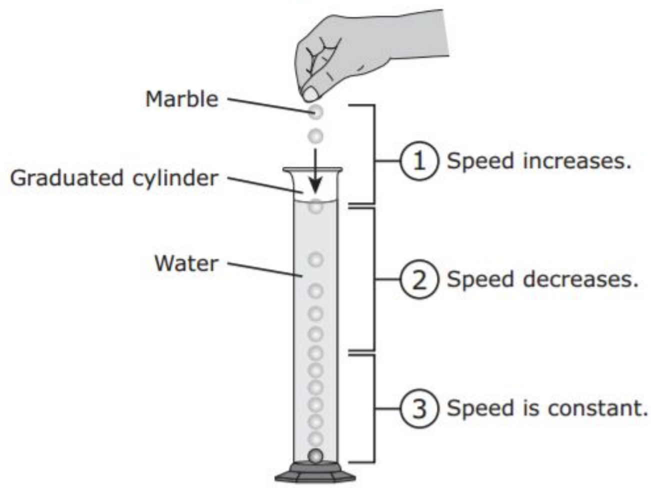
C Work done by Earth's gravity prevents Student 2 from changing position.

D Work is being done on both students by the swings because one swing is changing position.

Grade 8:

49 A student used a video camera to record another student dropping a marble through water in a graduated cylinder. The students watched the video in slow motion and made the observations shown below.

Marble Drop Experiment



During which part or parts of the marble's fall did the marble experience unbalanced forces?

A Part 1 only

B Parts 1 and 2 only

C Part 3 only

D Parts 2 and 3 only

22 Four students raced toy cars on a track. The mass and the acceleration of each car is recorded in the table below.

Toy Cars

Toy Car	Mass (kg)	Acceleration (m/s^2)
1	0.19	2.0
2	0.15	3.0
3	0.25	1.5
4	0.21	2.5

Which toy car had the greatest applied force?

F 1

G 2

H 3

J 4

14 Two cars with different masses travel at the same speed down a hill toward a stop sign. What will happen when both cars apply brakes at the same time to stop?

F The car with the smaller mass will require less force to stop than the car with the larger mass.

G The car with the larger mass will maintain its velocity while traveling down the hill.

H The car with the smaller mass will take longer to stop than the car with the larger mass.

J The car with the larger mass will have less inertia than the car with the smaller mass.

14 During a demonstration of Newton's laws of motion, a student used the setup shown in Figure 1. The student flicked the index card with a fingertip, and the coin fell straight down into a plastic cup as shown in Figure 2.

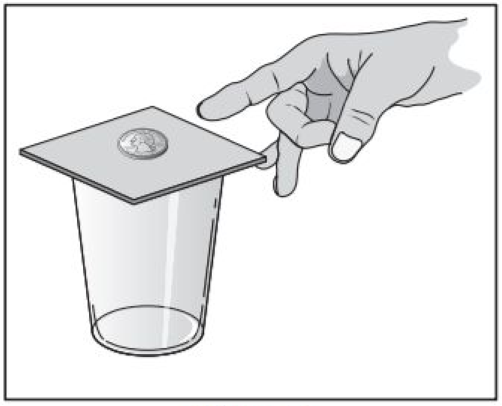


Figure 1

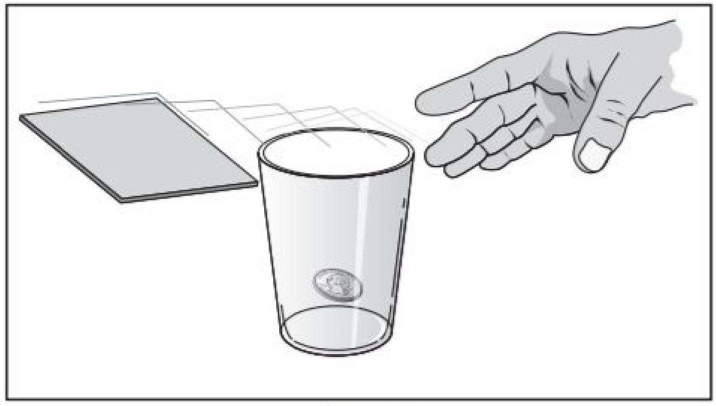


Figure 2

Which of these best explains why the coin fell straight down into the cup instead of remaining on the index card?

F The coin was at rest until the card was removed, so it tended to remain in the same location. Once the card was gone, the unbalanced force of gravity caused the coin to fall.

G Moving the card applied an action force on the coin. Since the card was gone, gravity applied a reaction force on the coin.

H The card had less mass than the coin, so a smaller force of gravity acted on the card. The larger force of gravity on the coin made it fall.

J The acceleration of the coin falling into the cup was equal and opposite to the acceleration of the card.

19 Four students push carts filled with sports equipment across the gym. Each student pushes with the same amount of force. Which cart has the greatest change in speed?

A

12 tennis rackets
m = 10 kg

B

15 sports balls
m = 15 kg

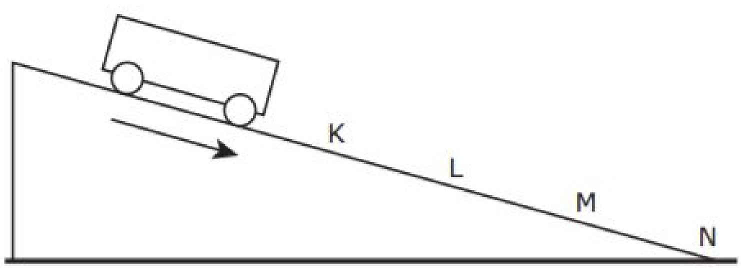
C

18 exercise mats
m = 20 kg

D

28 pieces of rope
m = 25 kg

10 For an investigation, a student measures the speed of a cart as it rolls down a ramp. The student then records data in the table below.



Cart's Speed Down a Ramp

Location	Average Speed (m/s)
K	0.25
L	0.52
M	0.73
N	1.08

Which of these best explains the student's data?

F The speed of the cart decreases as the cart rolls down the ramp because of friction between the cart and the ramp.

G The speed of the cart increases as the cart rolls down the ramp because the force acting on the cart is greater than the force of gravity.

H The speed of the cart increases as the cart rolls down the ramp because the forces acting on the cart are unbalanced.

J The speed of the cart decreases as the cart rolls down the ramp because the forces acting on the cart are balanced.

CAREER CONNECTIONS:

The Engineering Design Process is applicable to every type of engineer, from electrical to aerospace!

How do the laws of physics affect your everyday life?

What would you like to design with your knowledge of physics and Newton's Laws?

What kinds of jobs or careers require a knowledge of physics?

Research a job or career that requires knowledge of physics.

Construction:
Contractor/Home Builder
Developer
Civil Engineer
Designer
Structural Engineer
Mechanical Engineer
Aerospace Engineer
Architectural Engineer
Chemical Engineer
Civil Engineer

Design:
Game Developers
Amusement Park Developers/Designers
Toy Designer
Inventors
Theatrical Set Designers

Health/Athletics:
Biomedical Engineer
Prosthetic Limb designer
Physical Therapists
Sport Scientist
Athletic or workout equipment designer

LINKS:
http://www.discovere.org/
http://www.sciencekids.co.nz/sciencefacts/engineering/typesofengineeringjobs.html
https://www.or-laser.com/en/a-kids-guide-to-engineering/
http://discovermagazine.com/2013/dec/15-e-is-for-engineering