Connecting to Motion Interest Project

Created by Patriots' Trail Girl Scout Council, now Girl Scouts of Eastern Massachusetts. The requirements have been slightly modified to align with Magic Mountain GSGLA Day. For the original requirements, please visit www.girlscoutseasternmass.org.

Motion is everywhere. Any time an object changes its position, motion occurs. The Principles of Motion, discovered by Sir Isaac Newton, are used to explain the characteristics of objects in motion. Motion is described in terms of speed, direction, momentum, velocity, mass, and inertia. Dynamics is the study of the relationship between an object's motion and the forces that act on the object.

Complete two Skill Builders activities (including the bolded one), one Technology activity, one Service Project activity, one Career Exploration activity, and two additional activities from any category that you choose. Starred activities (*) may be completed during Magic Mountain GSGLA Day.

Skill Builders

1. **Identify the three Principles of Motion discovered by Sir Isaac Newton, and explore how these Principles can be observed in the world around you.**
2. *Complete Activity 1 - BATMAN, from the Amusement Park Ride Packet. Describe though the use of drawing or writing, the concepts of friction, energy, speed and mass as they relate to the motion of a roller coaster.
3. *Complete Activity 2, BUMPER CARS, from the Amusement Park Ride Packet. Describe, through the use of writing or drawing, the concept of energy transfer from one object to another, and the way in which speed and mass are related to the transfer of energy between bumper cars.
4. *Complete two of the three additional activities from the Amusement Park Ride Packet. Describe how math is related to the scientific concepts seen at an amusement park.
5. Visit the website http://www.learner.org/exhibits/parkphysics to learn about the physics of several amusement park rides. Use the "Design a Roller Coaster" feature to design a roller coaster, taking into account the safety and thrill factor of the ride. Refer to the physics glossary as needed.

Technology

1. Explore one of the web sites listed below. Write a brief description of what you learned.

http://www.mos.org/sln/Leonardo/InventorsWorkshop.html	Look at the life of Leonardo daVinci and the historical impact of his fascination with science, machines, and art
http://www.Kapili.com/physics4kids/motion/index.html	Examine the way that physicists look at motion, mechanics, energy, force, gravity, friction and work
http://www.dfrc.nasa.gov/trc/saic/newton.html	This web site, offered by NASA and the Dryden Flight Research Center, explains Newton's Laws of Motion, presented in a slide show format
http://www.innerauto.com/innerauto/htm/auto.html	Look at the details of automobile mechanics and motion, including gear motion, drive belts, motors and other components
http://www.exploratorium.edu/snacks/snackintro.html	Discover exhibit at the Exploratorium in a "snack form", including several experiments on mechanics and motion
http://www.howstuffworks.com	Learn basic explanations of how things work. Topics include engines, machines, appliances, electronics, music, computers, and the Internet, among others.
http://www.grc.nasa.gov/WWW/K-12/aeroact.htm	Try physics experiments and learn about Newton's three Laws of Motion

2. *Participate in one of the Girl Scout “Olympi-gineering” activities during Magic Mountain GSGLA Day and describe the ways in which the activity relates to Newton's Principles of Motion. The schedule of available will be available at the Girl Scout table at Six Flags Magic Mountain during GSGLA Day.
3. Visit a computer center or Computer Learning Center and create something on the computer using simulation software.
4. *Take part in Magic Mountain GSGLA Day and think about how physics and science are related to the rides. Write a brief description of your favorite ride at Six Flags Magic Mountain, and how it relates to physics and motion.

Service Projects

1. Create a hands-on activity that explores motion that you could present to younger girls. Make a list of materials you would need for the activity, and briefly describe how the activity would be presented to the girls. Include a summary of what you would want them to learn from this activity.
2. Draw a poster that describes the life and contribution of Sir Isaac Newton to science. Include a description of the Principles of Motion that he discovered. Display this poster in a science exhibit, or give it to a classroom of younger students in your school, or to a younger troop.
3. *Visit an amusement park or playground. Observe the ways that physics or science concepts are at work, and identify the different ways that motion is at work on the playground or at the park. Describe the rides or playground equipment in terms of potential and kinetic energy, and identify where friction occurs to slow down the motion. Observe where an outside force is applied to a ride or to the use of the playground equipment to cause motion to occur.

Career Exploration

1. *After taking part in Magic Mountain GSGLA Day, briefly describe what you liked the most and what you liked the least about the day. Evaluate what you would do to make the visit better the next time. Consider if analyzing the physics and engineering science behind the amusement park rides changed your experience, and why you think it did/did not. Share your observations and thoughts with another individual. Include in your evaluation something new that you learned that day.
2. Invite a woman who is a scientist, an engineer, or a professional who teaches or works in a science field to come to your classroom or troop meeting. Ask her to explain how she became interested in science, what courses of study she chose, what she does in her job, and how she combines her work and home life. Write a thank you note after her visit, expressing your appreciation for her interest and time.
3. Take part in an engineering or science day presented by college students or professors for middle or high school students. Find out what the college is like, and ask the college students how they became interested in the college and in science as a career.
4. Look at a college catalogue for a School of Engineering, or other science major. Identify the science and math courses, and the other credentials that are necessary to be admitted to this college. Note the courses that you have taken already that will help you to be admitted to this school as a science or engineering major. Identify the courses that you would still need to take. List five things about this college that you would enjoy if you were a student there. List five things that you would not like about this school.
5. Correspond, using e-mail, with a woman scientist or engineer, or with a college student who is majoring in science, engineering or technology. Ask her questions about her life, her career, her course of study, and her interest in science. Share with her what you are taking in school, and what your science interests include.

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OBJECTIVE #1:

To determine the speed of the BATMAN train from distance and time measurements.

DISCUSSION:

An estimate of the speed of the train at any point can be found if the train's length and the time required for the train to pass the point are known. If **L** is the length of the train and **t** the time required to pass the point, the speed can be found from **$v = L/t$**. Measure the time for the train to pass the top of the first incline, the bottom of the first decline, and the top of the first vertical loop, and pace off the length of the BATMAN train.

APPARATUS: Stopwatch

DATA: Length of train: ____________ feet

Time for train to pass: top of first incline: ____________ sec
bottom of first decline: ____________ sec
top of first loop: ____________ sec

RESULTS: Speed at: top of first incline: ____________ m/s
bottom of first decline: ____________ m/s
top of first loop: ____________m/s

OBJECTIVE #2:

Determine the potential energy of the BATMAN train at the top of the first incline.

DISCUSSION:

Potential energy is the energy of position – any object above the ground has potential energy. potential energy (PE) is measured in Joules (a Joule = $kg \cdot m^2/s^2$).

If the total loaded mass of the train (**M_{total}**)and the height (**h**) above ground level of the first incline are known, the potential energy of the train at the top of the first incline can be calculated using the equation **$PE = M_{total}gh$**. To find **M_{total}** count the number of seats on the BATMAN train. The mass of the unloaded train is given by Six Flags as 9,440 kg. Assuming each seat to be occupied by a standard 60 kg passenger, a rough estimate of **M_{total}** can be calculated. The height (**h**) of the top of the first incline is given by Six Flags as 32.0 meters.

DATA: # of passengers/train = ____________

M_{total} = M_{train} + (# of passengers) ($M_{passenger}$)
= 9,440 kg + (____________) (60 kg)
= ____________ kg

RESULTS: PE = $M_{total}gh$
= (__________ kg) (9.8 m/s^2) (32 m)
= ____________ Joules

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OBJECTIVE #3:

Determine the kinetic energy of the BATMAN train at the top of the first incline.

DISCUSSION:

Kinetic energy is the energy of motion – any object in motion has kinetic energy. Like potential energy, kinetic energy (KE) is also measured in Joules.

If the mass of the loaded train ($\mathbf{M_{total}}$) and the speed of the train (**v**) at the top of the first incline are known, the kinetic energy of the train can be calculated using the equation $\mathbf{KE = ½M_{total}v^2}$.

DATA: (from Objective #1) speed at top of first incline = ____________ m/s

(from Objective #2) M_{total} = ____________ kg

RESULTS: KE $= ½M_{total}v^2$ = ___________ Joules

OBJECTIVE #4:

To calculate the speed of the BATMAN train at the top of the first vertical loop using the principle of conservation of mechanical energy.

DISCUSSION:

The mechanical energy of an object is the sum of its energy due to its position and to its motion. In other words, an object's mechanical energy (ME) equals its potential energy plus its kinetic energy (ME = PE + KE). The principle of conservation of mechanical energy states that, if a system is subject only to gravitational forces, its total mechanical energy remains constant. This means that if an object moves from one position (A) to another position (B), the total energy the object at position A will equal that of it at position B: $PE_A + KE_A = PE_B + KE_B$

Since its speed at the top of the first incline ($\mathbf{v_I}$), its height at this point ($\mathbf{h_I}$), and its height at the top of the first vertical loop ($\mathbf{h_L}$) are known, the equation for conservation of mechanical energy can be used to calculate the speed of the BATMAN train at the top of the first vertical loop ($\mathbf{v_L}$).

DATA: (from Objective #1) speed at top of first incline (v_I) = ____________ m/s

(from Objective #2) height at top of first incline (h_I) = ____________ m

Height of top of first loop above ground (h_L) = 23.5 meters

RESULTS:

$PE_I + KE_I = PE_L + KE_L$

$mgh_I + ½mv_I^2 = mgh_L + ½mv_L^2$

Speed at top of first loop (v_L) $= \sqrt{2g(h_I-h_L) + v_I^2}$ = _________ m/s

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OBJECTIVE #6:

Calculate the amount of mechanical energy converted to heat as the BATMAN train travels from the top of the first incline to the top of the first loop.

DISCUSSION:

In an ideal system, mechanical energy is completely conserved. However, the speed of the train at the top of the first loop calculated using conservation of energy is not the same as the speed measured (Objective #1). The actual speed is less than the calculated speed, because some energy is lost to heat (friction, air resistance). Using the equations from above, calculate the amount of energy lost to heat as the train travels from the first incline to the first loop.

RESULTS: energy lost to heat $= ME_{initial} – ME_{loop}$ = ____________ Joules

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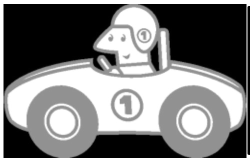

BUMPER CARS

OBJECTIVE:

Use Newton's Principles of Motion to understand bumper cars

DISCUSSION:

Below, you will be asked to determine the top velocity of the cars. Pick two points in the ride and estimate or measure the distance between them. Then, time several cars to determine how long it takes them to move from one point to the next. You will also need to estimate the mass of two people in kilograms (try to find people with very different masses), and then observe the types of collisions that occur when those two people collide with each other while driving bumper cars.

DATA:

An unloaded bumper car has a mass of 213 kilograms

Length used for velocity determination: l = ____________m

Times used for velocity determination: t1 = ____________sec

t2 = ____________sec

t3 = ____________sec

Estimate the mass of two people Person 1 = ____________kg

Person 2 = ____________kg

Results of collisions between the two people:

	Type of Collision	Result
Collision 1		
Collision 2		
Collision 3		

RESULTS:

1. Using the equation for conservation of total momentum ($m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$), what would happen to your velocity is you were driving a bumper car at maximum velocity and collided head-on with stationary bumper car with a driver twice your mass?

1. Are the bumper car collisions elastic or inelastic?

2. Describe how Newton's Principles of Motion apply to this ride.

3. During a collision, is kinetic energy conserved? Momentum? Explain.

4. List two ways to increase the momentum of the cars?

5. In a head-on collision of a fast and slow car, which driver experiences the greater force?

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Stand outside the ride at a place where you can watch the coaster. Watch a rider and try to determine what forces the rider feels on his/her body at various points during the ride. Would the seat be pushing on the rider's bottom? Would the shoulder harness be holding the rider in the seat? Would the side of the car be pushing on the rider? Would the back of the seat be pushing the rider forward? Would the shoulder harness prevent the rider from flying forward?

Consider what is happening as the coaster is in the following situations. For each of the situations predict what forces you or another rider would feel:

- going up the first hill
- going down the first hill
- making a sharp left or right hand turn
- going over the top of a hill when right side up
- going through the top of a loop upside down
- leaving a loop while right side up

Watch the way the riders move. Does their hair hang down?

1. Now ride the ride or interview someone who did. Try to remember the forces you felt at some of the points listed above. Work with a group. Assign each person a specific point at which to collect data. Do your observations agree with your predictions made above? Discuss

2. Stand at a place where you can see the coaster going through the first loop. Measure the time it takes for the entire coaster train to go through the loop. Start your stopwatch when the first car gets to the top of the loop and stop when the last car passes this point. The coaster train is 13.1 meters long. Calculate the speed of the coaster train as it goes through the top of the loop using the equation speed = (distance)(time). Show your work.

3. As you go through the top of the first loop try to remember the force you felt. Did the seat push on your bottom or did the shoulder harness hold you in your seat?

4. Describe the force you felt at the top of the loop.

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LOG JAMMER

OBJECTIVE:

To determine the acceleration and speed of a log traveling down the final chute of the flume ride.

SUGGESTED PROCEDURE:

The final chute of the log Jammer is about 36 meters long. The log starts basically from rest and shoots down the hill. By measuring the time it takes the log to get to the bottom, you can determine the acceleration on the chute, and find the final speed at which you hit the water.

DATA:

Use the formula $a = 2d/t^2$ where a = acceleration (m/s^2)
d = distance down chute
t = time down chute

Time for log to descend chute = ____________ seconds

(you should time several logs to get a good idea of the average)

Acceleration of log = ____________ m/s^2

RESULTS:

A body in free fall has an acceleration of 9.8 m/s^2. How does your answer compare with this? What factors contribute to the difference of your answer?

How fast were you going at the bottom of the chute?

First estimate how fast you think you were going: 5 m/s 10 m/s 100 m/s

(60 mph = 88 feet/second = 26.8 m/s)

You can determine the speed at bottom of the chute by using this formula:

$v = (a)(t)$ where v = velocity
a = acceleration (from above)
t = time (from above)

Speed at bottom of chute = ____________ m/s

How was your estimate? Faster or slower? Are you surprised?

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OBJECTIVE:

To determine the total amount of water used on the TIDAL WAVE ride and investigate storage spaces in which to keep it.

SUGGESTED PROCEDURE:

Six Flags lists the total volume of water pumped through the ride is 30,000 gallons per minute, which is 113,550 liters. By timing yourself on a complete ride through TIDAL WAVE you can estimate the total amount of water in the ride.

DATA:

Time of one ride (dispatch to return) = __________ sec; __________ min (sec ÷ 60)

RESULTS:

Total gallons = (time of ride) x (volume of water in gallons per minute)
= (__________ min) x (30,000 gallons per minute) = ____________gallons

Total liters = (time of ride) x (volume of water in liters per minute)
= (__________ min) x (113,550 liters per minute) = ____________liters

A gallon of water takes up 231 cubic inches. A liter of water takes up 0.001 cubic meters.

Volume of water = (gallons of water for ride) x (231 cubic inches/gallon) = ____________cubic inches
= (liters of water for ride) x (0.001 cubic meters/liter) = ____________cubic meters

Design a holding tank for the water on TIDAL WAVE. Try to be creative. Think of the different types of tanks you see around your community: a swimming pool, an oil storage tank (cylinder or sphere), an oil tanker, or one of your own design.