Cedar Point

PHYSICS, SCIENCE & MATH DAYS

Physics, Science & Math Day Workbook

Name: ____________________

School: ____________________

Greetings,

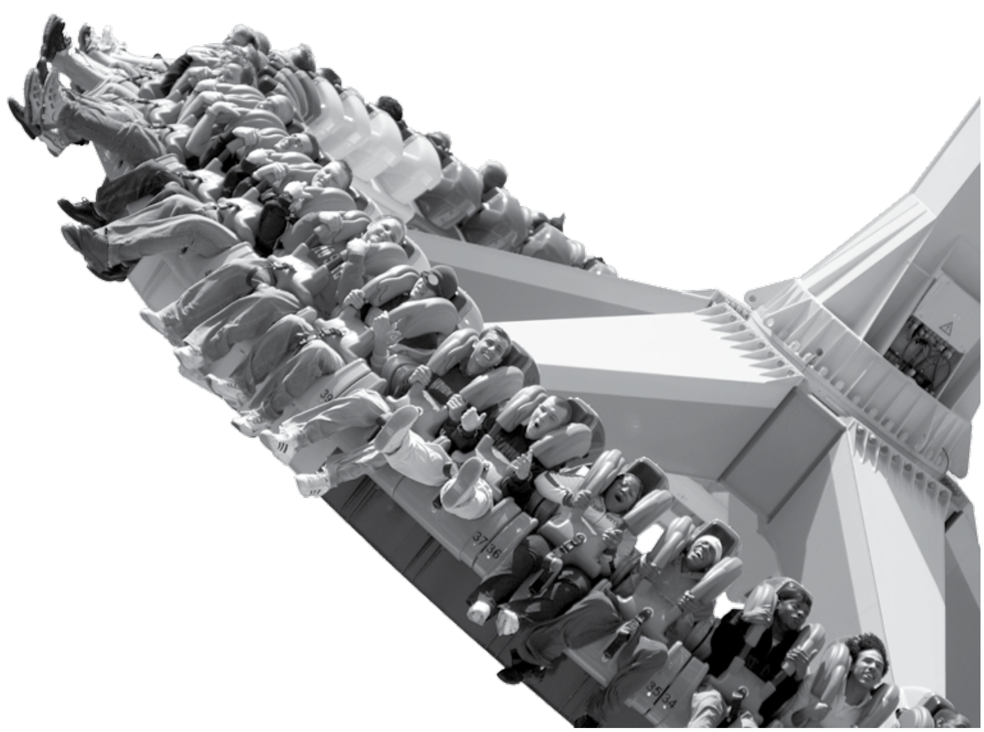
We have created this packet to assist you with your curriculum for your visit to Cedar Point during Physics, Science & Math Days. The information can be used as is, or if you wish you may customize the activities/questions for your students. While every effort has been made to ensure accuracy of the information, please remember Cedar Point is not an education institution. Over the years we have had contributors assist with this packet. We would like to give special thanks to Perkins Local Schools in Sandusky, Ohio for their help in developing portions of this packet. We also would like to thank Baldwin Wallace University from Berea, Ohio. If you have questions on how to work through a problem visit their booth on the midway from 10am – 2pm during the Physics, Science and Math Days event.

- Dr. Edwin Meyer – Problems
- Dr. Lisa Ponton – Problems, Illustrations
- Dr. Peter Hoekje – Problems
- Brandon Dropic – Problems, Graphs
- Alan Duncan – Problems, Illustrations
- Jame Emigh – Review
- Dave Revta – Problems, Compilations, Review, Graphs , Illustrations

We know this workbook can and will add to the educational enjoyment of the day.

See you on the midway!

Sincerely,
Cedar Point Staff



Cedar Point Math & Science Workbook
A Note From The Compiler

Baldwin Wallace University is pleased to be an academic partner with Cedar Point. Students, faculty, and staff from our departments of Physics and Chemistry have worked together to develop problems for this workbook with the aim that it support Ohio Physical Science Standards for Grades 5-8. This isn't just a workbook; it's an invitation to explore and think about one of America's premier destinations in a way that is both educationally relevant, and also fun.

We've attempted to bring in aspects of the park that involve not just thrill rides, but chemistry, math, foods, mild rides and even light. Some problems lend themselves toward discussion or pencil and paper calculation, and others involve information gathering. Of course, timing and instrument use are important in science, but so are simple observational techniques.

Many attractions lend themselves to a variety of topics and grade levels. For example, the Cedar Point & Lake Erie Railroad uses levers, forces and energy, and the coal and steam aspects of the boiler lend themselves to chemistry problems. The overlap of scientific disciplines, the range of grade levels and varying needs of students and educators within a level makes it impractical to assign a specific grade level to each problem individually. Still, we have tried to identify various problem sets in terms of their relevance to various educational topics. Most of the content can work at various grade levels, depending on how it is presented. It's our belief that the workbook will be of the most benefit in an environment where an educator selects problems or topics that are the most appropriate for the needs of their students, then looks to take advantage of the teachable moments that happen during an interactive learning experience such as Cedar Point Science and Math Week.

An answer will be available, and may include ideas for expanding on some of the problems. We also plan to have some content available online. Just like the park itself, we've tried to provide something for everyone. We hope you'll use the workbook and other resources as starting points for learning. The questions are intended to be thought provoking. Many of the problems involve assumptions, simplifications, estimates and/or rounding. We acknowledge that some problems may have more than one approach that could lead to slightly different answers. We've tried to keep our information accurate, but the problems are for illustration and education, rather than engineering or technical purposes. We've tried to provide coverage of a breadth of topics, but we don't want to lose sight of the fact that this really is supposed to be fun and not just topics in science!

The project has been different for us, and we imagine the results will be different than what the park has used in the past. We welcome your feedback, and we hope to see you during the 2015 Science and Math Week event at Cedar Point. Look for us there!

Baldwin Wallace University Contributors
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Blue Streak

1. Observe the lift hill of Blue Streak from the cue line. The lift hill is straight as viewed from the top, but the profile of the hill curves up and down (we might call this a vertical curve). Is the track made of one really thick beam, or several smaller layers? Why do you think the track is built the way it is?

2. If you ride the front seat of Blue Streak, you can observe how a flat curve is constructed as you leave the station by watching the track as you ride. If you'd like, take a ride in a seat near the front of the train.

   As you ride Blue Streak, pay attention to the lateral (side to side) forces that you experience. Where are you on the ride when you experience the largest and most consistent sideways force? Explain where this force originates from, and the resulting motion of the train and your body. Can you give the scientific name for this force?

3. If you enjoy Blue Streak, it's fun and constructive to ride in a couple of different seats and compare the rides. For example, you could take a ride in one of the first three or four rows of the train, and then take a subsequent ride in one of the last three or four rows. Pay attention to your feeling of weightlessness (or "airtime") as you go over the hills (sometimes called bunny hills) of the ride when riding toward the front, and toward the back.

   When you're near the front, do you experience more air time when the train is rising a hill, such as when it is entering the turn at the far end of the ride, or do you experience the air time more when the train is going down hill?

   How about if you ride near the back of the train - is the air time occurring more as the train is approaching the crest of a hill, or as the train descends? ________________

   If you pay close visual attention to the top of the track on the small hill right after the turn, you'll see visual evidence of the air time experience. What is this evidence, and what does it tell you about the Blue Streak train as it is going over that baby bunny hill after the turn?

4. When you are going over that short bunny hill, does the force from the train seem to push you upward, or pull you down?

   As on the rest of the ride, the track is laminated, but on flat curves such as the one near the station, the track must follow a curve primarily along the wide part of the board rather than along the thinner dimension of the board. Why are the track boards more likely to be cut into shape along a flat curve, rather than simply forced to bend? (Hint: lay a piece of paper on a flat surface. Is it easy to curl it up in the vertical direction? Of course it is! Even a pad of paper, or a paperback book will bend with relative ease in certain directions, but not in others. What happens if you try to bend a large rectangle like a piece of paper or a paperback book in the flat way?)

Cedar Downs

Useful to Know:

- Speed of ride in MPH _______
- The pinnacle in the development of the carousel is a ride known as the racing derby, of which Cedar Downs is a pristine example. The ride actually may have more in common with roller coasters than merry go rounds, as it is entirely supported from below on roller coaster track.

Ride Data:

- Diameter of track for inner (first) row horses:_________
- Diameter of track for second row horses:_________
- Diameter of track for third row horses:___________
- Diameter of track for outer (fourth) row horses:_________
- Overall outer diameter of moving ride platform_______
- Width of moving ride platform: 16' 4"

1. If you ride on the outer (fourth) row of horses on Cedar Downs for one revolution, what distance in feet would you travel? ____________

2. Ride Cedar Downs. Remember which row you rode in, and count how many revolutions you travelled during your ride. Use this information to calculate the distance you travelled while riding Cedar Downs.

____

____

3. Just for fun: If you rode with friends, who won your race?____________________________

4. Which row goes the fastest in terms of MPH? ___________________

5. Why doesn't the horse on that row always win?

____

____

6. Just for fun: How many spotted horses are on Cedar downs?________________________________

7. Take a look at the platform deck as you board Cedar Downs. Is the deck made of individual boards, or larger pieces such as plywood? How is a large circular deck constructed from rectangular pieces, and sections that use straight edges?

____

____

8. Given the dimensions of the ride, find the overall surface area of the decking. You may neglect the small slots where the supports for the horses go, but be sure to account for the fact that the ride has a large open area in the center!

____

9. Suppose that the deck boards are 3/4" thick pine. What is the total volume of wood decking? ___________________

10. In the United States, lumber is often traded and specified in units of board feet. How many board feet of deck-ing is on Cedar Downs? How much does the decking weigh?

____

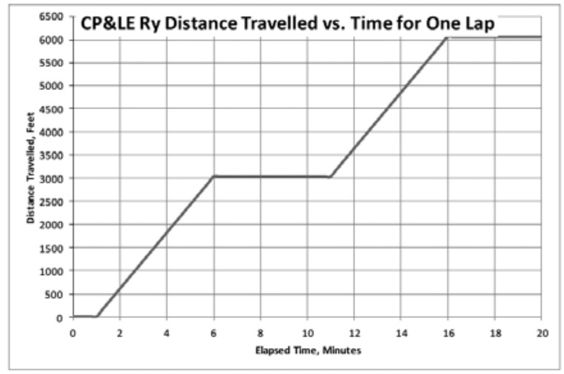
CP&LE Railroad

Useful to Know:

- Number of cars per train _________
- Number of seating rows per car ________

Ride data available at CP&LE Railroad entrance.

- Track Length:
- Empty Train Weight:
- Weight of locomotive & tender:
- Maximum number of passengers per row is:



A group of students decides to take a relaxing trip on the Cedar Point & Lake Erie Railway. They begin their journey at the Funway station. An approximate plot of their distance travelled vs. time is presented above.

1. How long after they are seated does the ride begin? ___________________

2. What is the travel time from Funway station to Frontier Town Station? ___________________

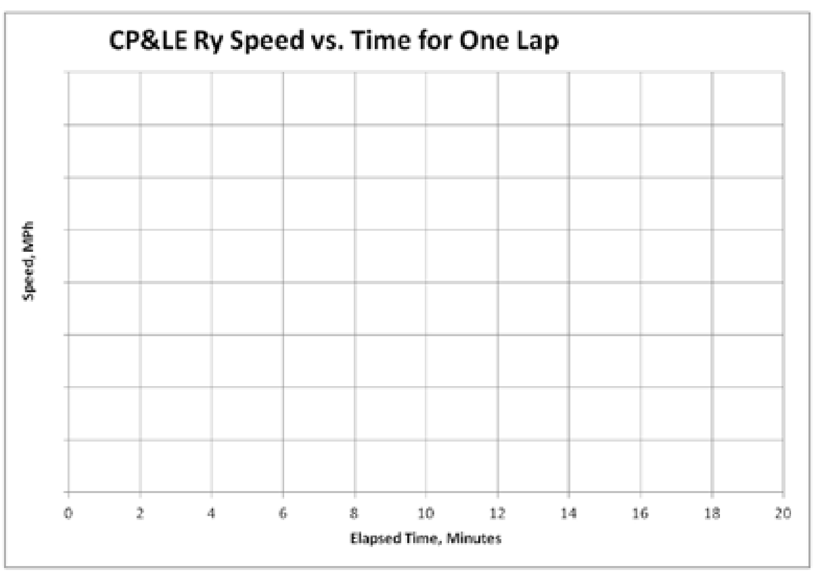
3. How long is the train stopped at Frontier Town Station? ____________________

4. How long does it take to get from Frontier Town Station to Funway Station? ______________________

5. What is the average speed of the train while it is in motion from Funway Station to Frontier Town Station, in miles per hour? ________

6. What is the average speed of the train over its entire twenty minute ride cycle, in miles per hour? ________

7. Make a graph of speed vs. time for one lap of the CP & LE Ry.



CP&LE Railroad

1. Let's take a closer look at the acceleration and forces involved with on the Cedar Point and Lake Erie Railway. While leaving Funway Station, it was determined that it took 84 seconds to accelerate to a speed of 4 meters per second. What was the rate of acceleration of the train?

____

____

2. Find the total mass, in kilograms, of the empty train and its locomotive and tender.

____

3. Use the information above, and F=ma, to determine the minimum amount of force needed to accelerate the train

____

4. Remember, this calculation does not take friction into account. If friction were accounted for, would the total force be greater, or less than what you calculated above?______________________

5. On the way out of Frontier Town Station, it was determined that the train took 48 seconds while accelerating to a speed of 3 meters per second. Is this acceleration larger, or smaller than the one found for the train leaving Funway Station?

____

6. Observe the train to determine the number of seating rows per car, and the number of cars per train. Use this information, and an average weight of 150 lbs per passenger, to determine the maximum mass of the people that the train can carry. Though mass and weight are not quite the same thing, you may use 1 kg ≈ 2.2 lbs to determine mass from weight.

____

____

7. Determine the total mass, in kilograms, of a fully loaded CP&LE Ry train including its locomotive and tender.

____

8. Use the acceleration you calculated for the train leaving Frontier Town Station, and the mass of the fully loaded train, to find the minimum force needed to accelerate the train.

____

____

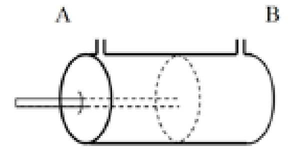
CP&LE Railroad

1. The chemical potential energy of coal becomes thermal (heat) energy as the coal burns in the locomotive. The heat boils water to make pressurized steam, which also has potential energy, but there is still something else that must happen before the potential energy of the coal is transformed into the kinetic energy of the train in motion.

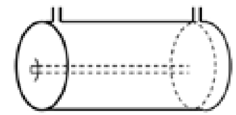
   The drawings at the right show a cylinder in various positions. A cylinder is a tube containing a piston which moves in response to pressurized fluid pushing on it. A rod extends through one end of the cylinder so the motion can be used outside of the device. The fluid (steam is a fluid, but steam isn't a liquid!) is put into one or the other side of the cylinder through a port, which is selected by valves (not shown) that help control the motion.

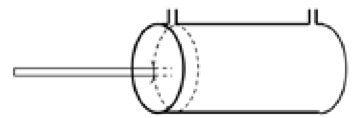
   To which port would steam have to be added in order to cause the cylinder rod to be retracted? _________

   To which port would steam have to be added in order to cause the cylinder rod to be extended? _________



Cylinder piston & rod in middle position


Cylinder rod retracted


Cylinder rod extended

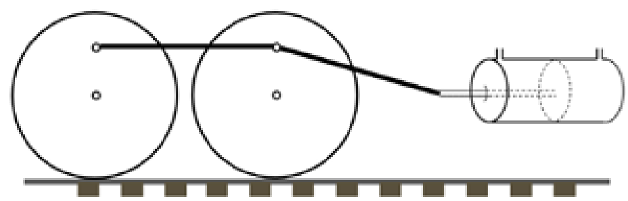
2. Consider the simplified engine drawings to the right.

   In the drawing to the right, if the cylinder extends, which direction will the wheels turn (clockwise, or counter clock-wise)?

   ____

   Will the locomotive move to the left, or to the right as a result? Draw an arrow to indicate the motion.

   ____



   Which side of the cylinder must have pressurized steam applied to make this happen? Draw some steam mole-cules in this area to illustrate. Show with an arrow where the steam is entering.

   ____

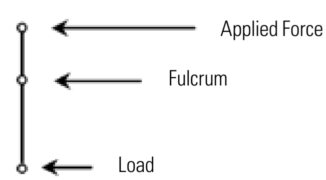
   If steam is entering one side of the cylinder to push the piston and rod, what is happening to the gas on the other side of the cylinder is it being compressed, or is it exiting somehow (hint - listen to the locomotive as it begins to pull the train. The Mean Streak crossing area is a great place to listen to the engine as it takes off. Why does it sound the way it does? 3. Use F=ma to determine the minimum amount of force needed to accelerate the train

   ____

3. What class lever is shown to the right?________________

   How does this lever relate to the simplified engine drawing above? Label which part of the engine drawing (track, wheel axle, cylinder) corresponds to each of the parts of the lever (force, fulcrum, load).

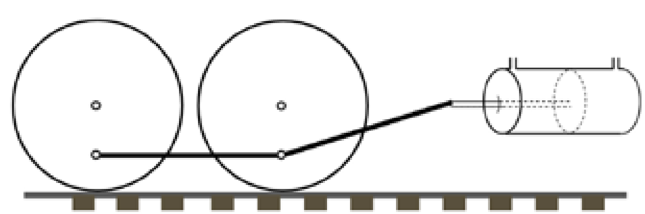
   ____



4. In the drawing to the right, does the cylinder have to extend or retract for the locomotive to move to the right?

   ____

   Middle School Challenge: What class lever is the wheel operating like now?_________________



CP&LE Railroad

The Cedar Point Lake Erie Railroad was first established in 1963. Since then, it has utilized the power of steam produced by the burning of coal in order to pull the railcars. The CP locomotive burns ¾ ton of coal and 1200 G of water in a 12 hour time period. In order for the steam to drive the locomotive, the pressure of the boiler must be 100 psi. Can you finish these problems from for a round trip to and from Funway Station? This journey takes 10 minutes of motion and 10 minutes of resting. If you get stuck, keep cho choo choooing along!

1. What kind of energy does coal have? ____________________

2. Water  , is boiled by the heat of coal burning. What phase is water transitioning from and to?

____

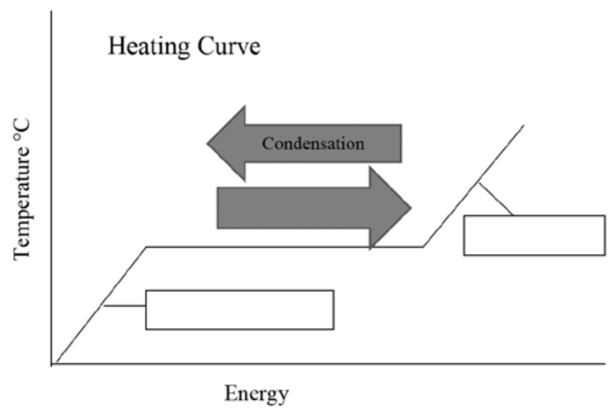
3. Is this a physical or chemical change that occurs? ____________________
   Draw three water molecules connected together.

4. How much water would the locomotive use during twenty minutes of operation (roughly the time of one round trip from Funway Station and Back)? ____________________

5. Middle School Challenge: Identify and label the following in the Heating Curve shown;

   a) Phase and corresponding temperature (in each textbox)

   b) Phase Change Process (in the arrow)



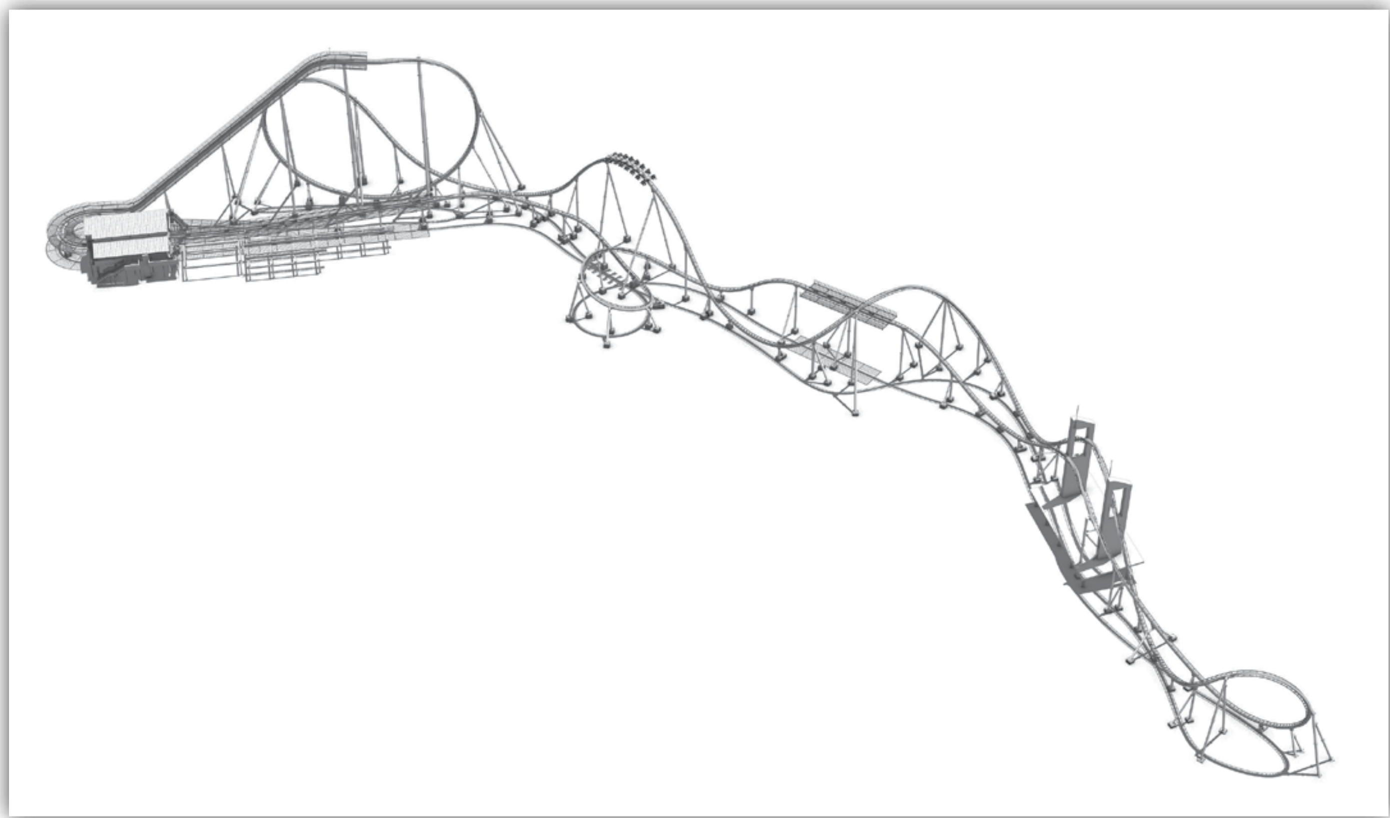
6. Conclusion (Fill in the Blanks)

   In order to make the Cedar Point and Lake Erie Railway operation, there are several energy transformations that must take place. First, coal has ________________ ________________ energy. When the coal is burned, it produces __________________ energy. The heat causes water to boil, which breaks intermolecular forces resulting in a change of _______________ that results in steam production. The steam is allowed into a _________________ which has a rod that moves the wheels of the locomotive. When the locomotive is moving, it has _______________ energy.

GateKeeper

1. Points of maximum potential and kinetic energy – Label on picture.
2. Points of maximum and minimum velocity – Label on picture.
3. Explain how the shape or position of the track affects the speed.

4. Explain where the speed was at its maximum and minimum.



Gemini

A helix is a banked circular section of track sometimes used as the grand finale to a roller coaster ride. While going through a helix, the force that the rider experiences is mostly directed upwards from the perspective of the rider, rather than lateral (side to side). The average lateral force is fairly low in the Gemini helix).

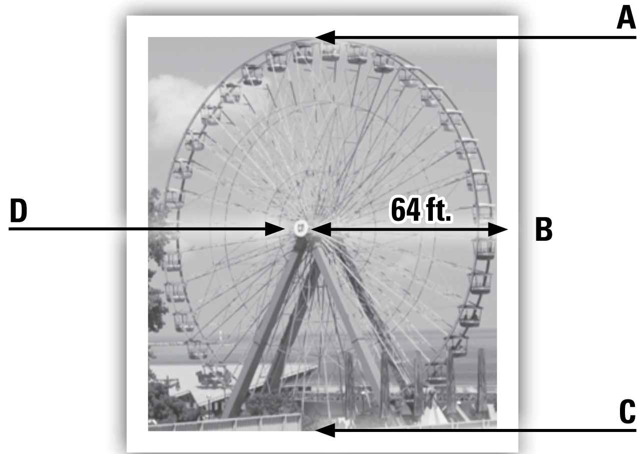
Ride data available at Gemini entrance.

- Angle of track in helix at end of ride:

1. Take a ride on Gemini, and pay special attention to your experience in the helix to verify this. As you go through the queue line of Gemini, notice the mechanisms at the base of the lift hill - these are clearly and easily visible from the queue (please don't enter any areas that are not normally accessible to guests). Does the lift hill of a traditionally powered roller coaster represent a simple machine, or a compound machine?

2. What other Cedar Point roller coasters have a helix element at the end of the ride?

Giant Wheel



Types of Angles

1. What angle and how many degrees does Point A, Point D and Point C make?

2. What angle and how many degrees does Point A, Point D and Point B make?

3. What is the distance from point A to Point C? What is this called?

Area of the Giant Wheel ***(Hint: π times radius squared)***

4. Find the Area of the Giant Wheel.

Circumference

5. If you do one full rotation, how far have you traveled?

6. If you do a half rotation, how far have you traveled?

7. Pythagorean Theorem (_____+_____=_____)

8. What is the distance from Point A to Point C? *(Hint: look at what shape it would make!)*

Maverick

At the following coasters you must point out the following points of energy and velocity.

1. Points of maximum potential and kinetic energy – Label on picture.
2. Points of maximum and minimum velocity – Label on picture.
3. Explain how the shape or position of the track affects the speed.

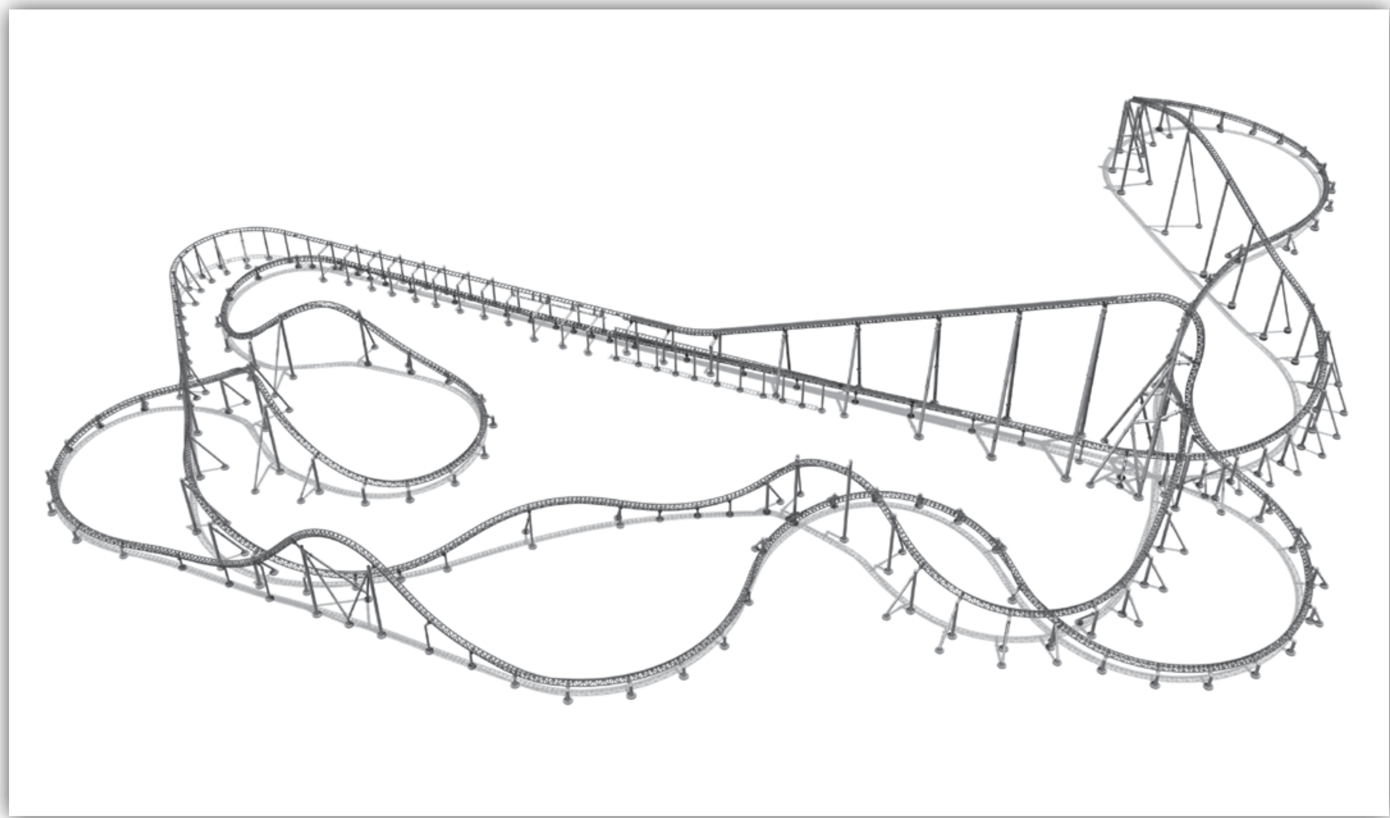
____

____

4. Explain where the speed was at its maximum and minimum.

____

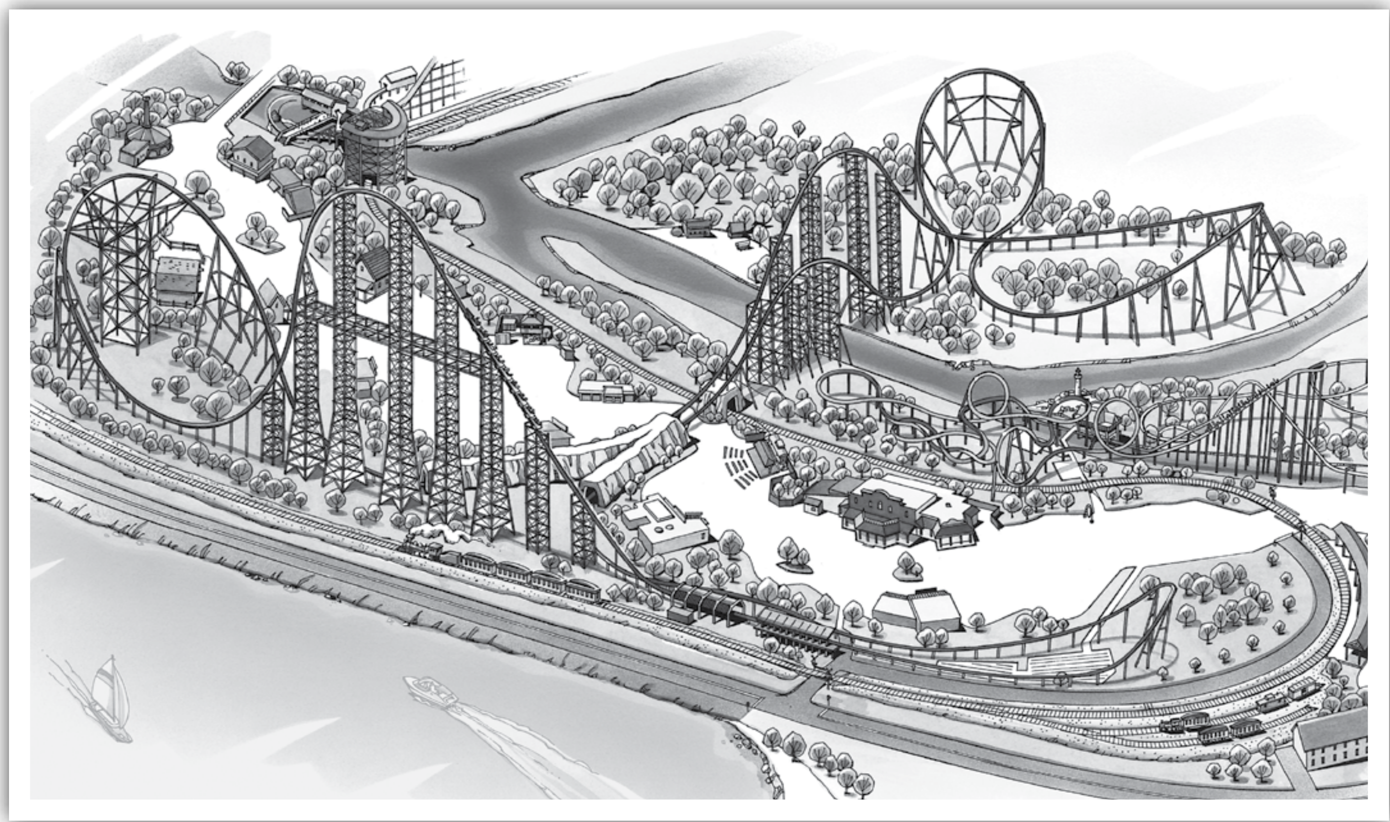
____



Millennium Force

1. Points of maximum potential and kinetic energy – Label on picture.
2. Points of maximum and minimum velocity – Label on picture.
3. Explain how the shape or position of the track affects the speed.

4. Explain where the speed was at its maximum and minimum.



Power Tower

Use Diagram Below

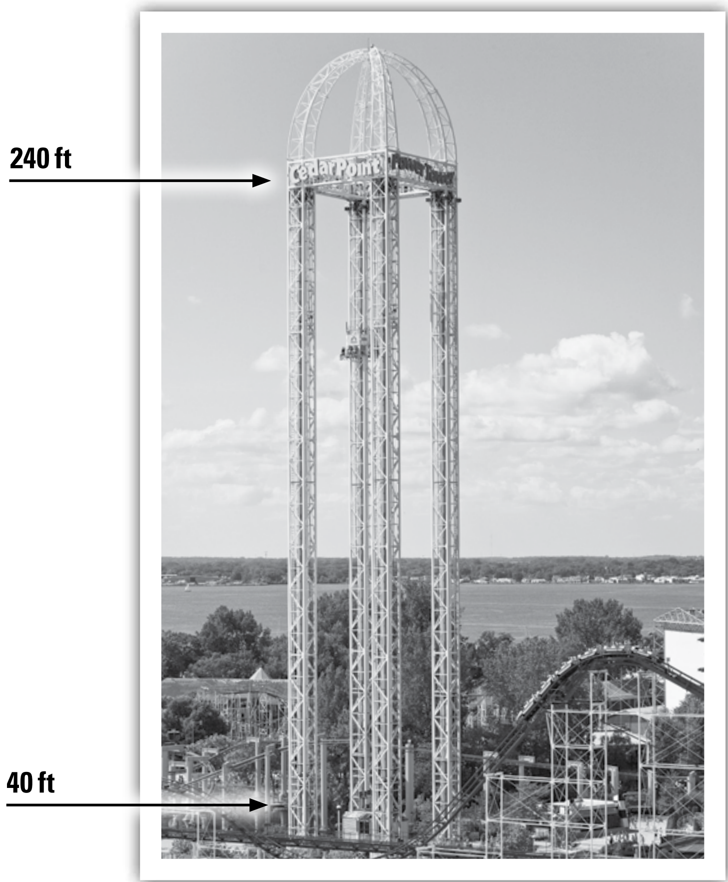
1. How far does Power Tower Drop you?

2. How long *(seconds)* does it take to drop? *(use your stopwatch or cell phone as a timer)*

3. Vertical Change *(Drop Side)*. ***(Ending Point – Starting Point) / Time (Seconds)***

3. Vertical Change *(Thrust Side)*. ***(Ending Point – Starting Point) / Time (Seconds)***

3. Are the two sides the same or different? Explain?

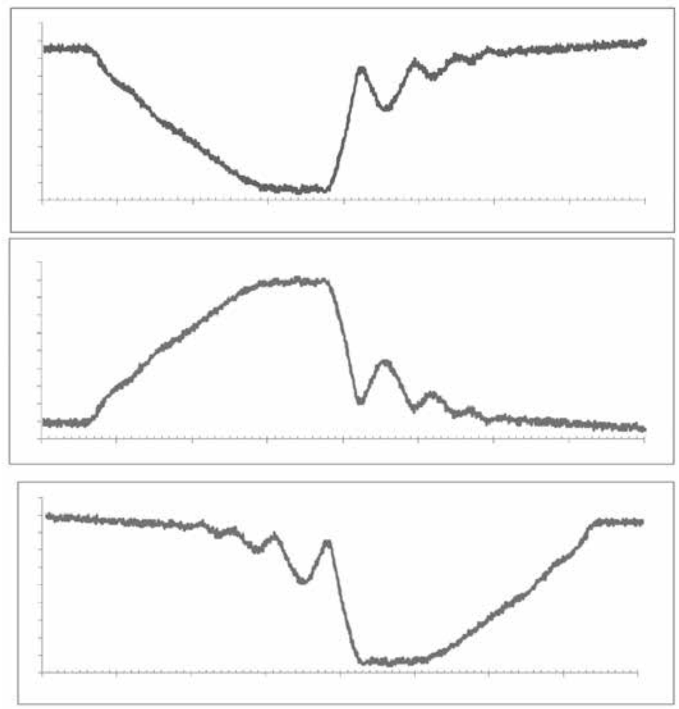


Power Tower

Ride data available at Power Tower entrance.

- Height:
- Vertical Distance Travelled :
- Maximum Speed:

Watch the drop side of Power Tower in operation. Then answer the questions on this page. When you're done, reward yourself with a ride!



1. Which of the graphs shown at the right is the most reasonably correct depiction of vertical *position vs. time* for a ride on the drop side of Power Tower? Draw a rectangle around the correct choice.

   ____

2. The horizontal scale of each graph is in seconds (minor tic marks), with a major tic mark every ten seconds. Assume that the origin (0,0) is at the lower left. ____________________

3. At what time does the car begin its long climb up the tower?

   ____

4. How long does it take for the car to ascend the tower?

   ____

5. How long does the car stay at the top of the tower before it descends?

   ____

6. Describe the motion of the car as it ascends the tower - does the velocity change much during the ascent, or is it relatively steady?

   ____

   ____

6. What is the average speed of the car during the ascent? ____________________

7. How long does it take the car to make its first drop from the very top? ____________________

8. Does the position graph intercept the vertical axis at a height of zero, or is there an offset?

   ____

9. On the graph, clearly label the region when the Power Tower cart has the most gravitational potential energy. Then, clearly label the region where the Power Tower cart has the most kinetic energy.

Raptor

The Raptor was first opened for operation on May 7, 1994. It is an inverted steel roller coaster that cost approximately twelve million dollars to build. It is 3,790ft long with a maximum speed of 57mph.

Ride data available at Raptor entrance.

- # trains:
- # cars per train:
- # passengers per car:
- Weight per car:
- Ride Time:
- Lift height:
- Drop of lift hill:
- Capacity:

1. Find the average speed of Raptor, based on the track length and the ride time. ________________

2. Record the time it takes to wait in line until you board the Train. Time: ________________
Based on the ride time and number of trains, how many people would be able to ride in an hour? ________________

3. Why would the actual hourly capacity of the ride be less than the value you obtained above?

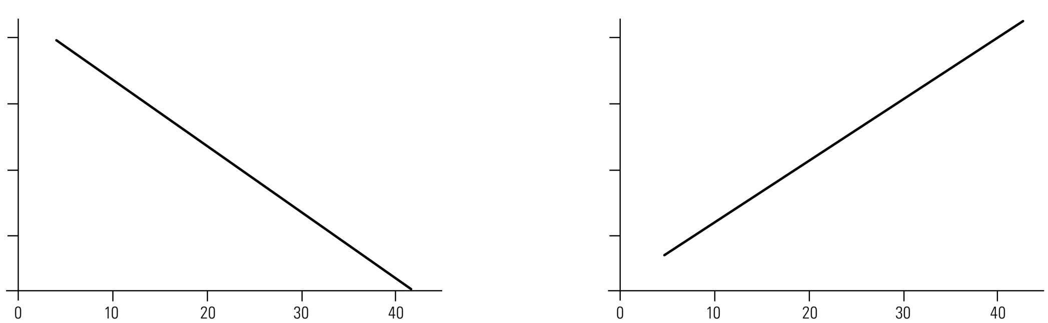
____

____

4. Calculate the average time taken to unload and load the Raptor train. ________________

5. Using the information obtained from above can you estimate the number of people that were in the line for the ride when you first entered the line? ________________

6. Consider the following graphs. One depicts potential energy, another depicts kinetic energy. For each graph, the horizontal axis shows the height of the train in meters on the main drop. Label each graph appropriately, and explain why you think your labels are correct.



7. Why is the potential energy not 0 at the bottom of the hill?

____

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Slingshot

SlingShot is anything but common. As a spring problem, it provides many opportunities for analysis at different academic levels. As a ride experience, it is also anything but common! Carefully watch SlingShot in operation, and use your knowledge of physics concepts such as conservation of energy, conversion of energy from one form to another, machines, work, and mechanical advantage to answer the following questions.

1. What kind of device is used on the SlingShot to change the direction of force? ________________________

2. Notice that SlingShot has many such devices, used in groups at the base of the springs. Wire rope is fed between them, in an arrangement similar to a block and tackle. What is the purpose of this setup? Hint: Besides direction, what other property does force have?

____

____

3. Give a classical name for a combination of pulleys and cable used to provide mechanical advantage. ________________________

4. When is the energy in the springs the greatest?____

5. What kind of energy do the springs have when their energy is greatest?______________________________

6. What happens to this energy as the ride ascends (hint - what kinds of energy does the ride have as it is going up?)

____

____

7. During its operation, where is the SlingShot vehicle in relationship to the top of the tower when the springs are at their shortest length?

____

____

8. The spring on SlingShot is actually a collection of many springs that act together. Which end of this collective spring is the energy input applied to - the top, or the bottom?_________________________

9. While SlingShot is in motion, do the springs elongate a lot or a little with respect to how far the ride vehicle moves? How does this relate to the concept of mechanical advantage?

____

____

____

Slingshot

1. What kind of machine stretches the springs in preparation for the ride launch, and why do you think this type of machine is used?

2. For SlingShot to operate, energy must change forms many times. Organize the steps, listed to the right, through which the ener-gy is transferred into the proper order as they are utilized by Sling-shot by numbering them from 1 to 7.

___) Work done by mechanical linear motion (cylinder movement)

___) PV (movement of pressurized hydraulic fluid

___) Kinetic energy of ride unit in motion

___) Electrical Power from First Energy

___) Mechanical motor turning pump

___) Gravitational potential energy of ride unit due to increased height

___) Elastic Potential energy in elongated spring

3. While energy cannot be destroyed, the transformation of energy from one form to another often involves the unavoidable, but undesired generation of heat. Though the heat energy can be accounted for, the unintentional heating of mechanical devices is often considered a loss. Examples include losses due to the resistance in motors and friction in sliding surfaces such as hydraulic cylinders. Even springs exhibit losses, though these are usually very small in comparison to the energy that they store. There is one energy transfer in SlingShot that would be considered conservative. Which one is it?

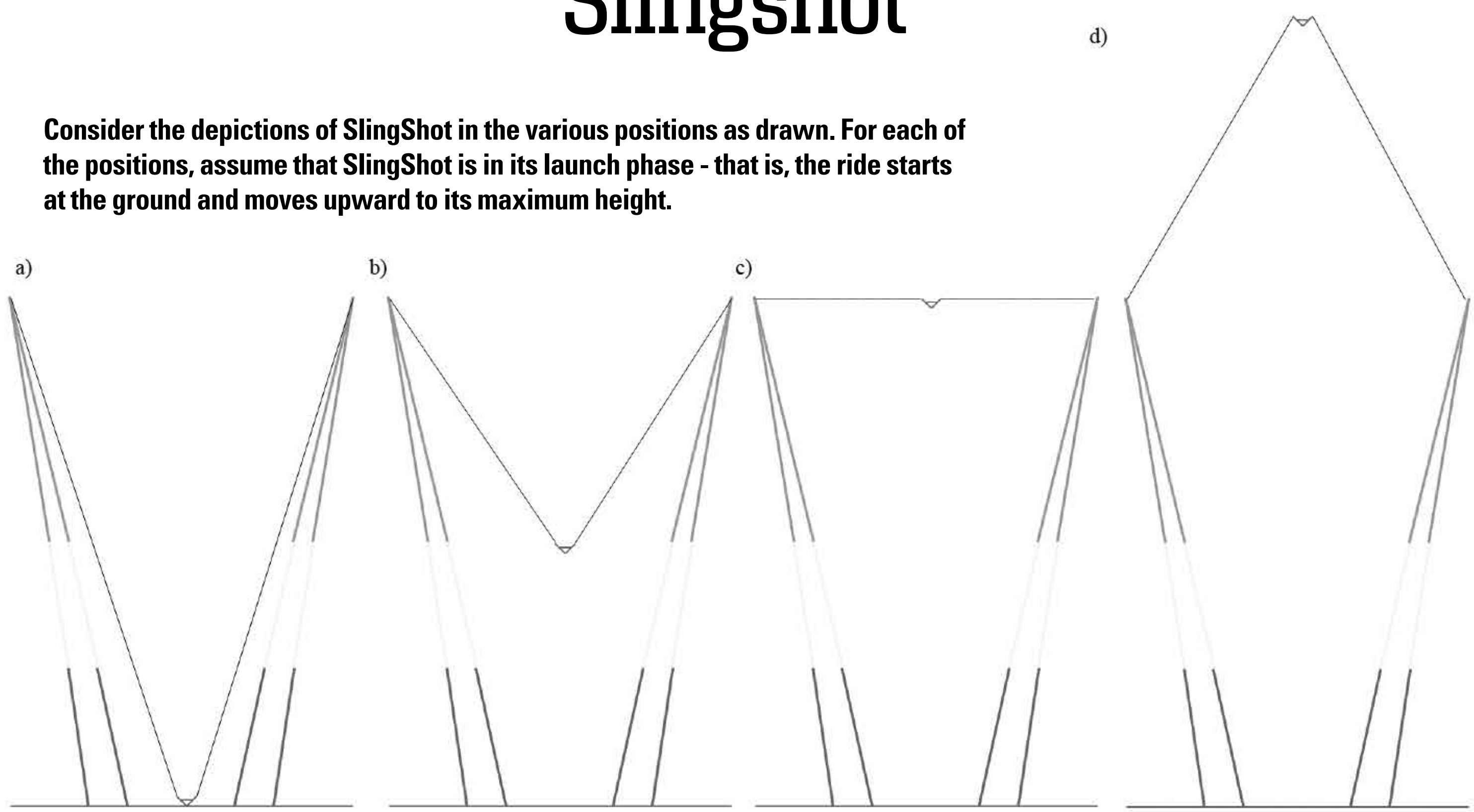
4. When the SlingShot vehicle is at the very top of its launch, all the way at 360', describe what kind of energy the ride system has, and what two places this energy is at. Observe the ride, and the ride mechanism carefully in order to answer this question correctly.

5. When Slingshot is all the way up at 360', what forces act on the ride vehicle? Identify which forces are contact forces, and which forces are non-contact forces.

6. Middle School Challenge: Qualitatively determine which is greater as the ride takes off - the total force on the springs, or the total force on the ride vehicle. Relate this to the concept of mechanical advantage.

Slingshot

Consider the depictions of SlingShot in the various positions as drawn. For each of the positions, assume that SlingShot is in its launch phase - that is, the ride starts at the ground and moves upward to its maximum height.



1. In which position(s) will the gravitational potential energy of the riders be the greatest? __________

2. In which position(s) will the gravitational potential energy of the riders be the least? __________

3. In which position(s) will the kinetic energy of the riders be relatively large? __________

4. In which position(s) will the net force from the ride be directed upwards? __________

5. In which position(s) will the net force from the ride be directed downwards? __________

6. In which position will the direction of motion be changing? __________

7. In which position(s) will the net force on the riders have the largest magnitude directed upwards? __________

8. In which position(s) will the net force on the riders have the largest magnitude directed downwards? __________

9. Middle School Challenge: On each depiction, draw vectors to represent the component and resultant forces involved.

10. Middle School Challenge: Can SlingShot apply a net vertical force at position c? Why or why not?

____

____

____

Top Thrill Dragster

Useful to Know:

- How to determine acceleration given change in speed and change in time
- 2.2 lb has a mass of 1 Kg
- How to find force given mass and acceleration
- Number of passengers per train - can be counted from a variety of guest accessible vantage points

Ride data available at Top Thrill Dragster entrance.

- Weight of train:
- Length of train:
- Duration of launch acceleration:
- Speed:

Assume that the Top Thrill Dragster train is fully loaded with passengers weighing an average of 150 lbs. During the launch, the cable system pulls the car with a constant force that accelerates the car to full speed.

1. What is the acceleration in units of mph/sec? ____________________

2. What is the acceleration in units of meters/sec^2? ____________________

3. Determine the average speed during the launch. ____________________

4. What is the distance of the pull (what is the distance travelled during the acceleration of the train)? ____________________

5. Draw a plot of position vs. time, and velocity vs. time, during the launch.

6. Determine the mass in Kg of the train and passengers when it is fully loaded. ____________________

7. Find the force needed to accelerate the train during its launch. ____________________

Valravn

Ride Data:

- Length of track: 3,415
- Speed: 75 mph max
- Overall tallest hill: 223'
- Drop height: 214
- Drop angle: 90°
- Second hill: 131'
- Ride time: 3:23
- Capacity: 1,200 guests / hour
- Structural: 2.99 million lbs
- Riders per train: 24

1. The thrill of a rollercoaster lies in the interaction of the various forces involved. Take a ride, or a good look at Valravn and pay attention to the forces you might be experiencing along the way. For each of the situations listed below, identify if the force exists because the objects are touching, or if the force exists when the objects are not touching (force at a distance). Briefly explain your reasoning or evidence in each case.

   a) force(s) that cause Valravn to climb the lift hill

   b) force(s) that cause Valravn to dive in the downward direction

   c) force(s) that cause Valravn to slow down

   d) force(s) that cause Valravn to move into the station after it has stopped

   e) force(s) that cause the Valravn train to turn left or right

2. For the Valravn depiction above, identify the following by filling in the numbers as appropriate:

   a) place(s) where riders would have an experience similar to free fall or “air time”

   b) place(s) where virtually all of the energy of Valravn’s train would be gravitational potential energy

   c) place(s) where the potential energy of Valravn’s train is increasing

   d) place(s) where the kinetic energy of Valravn’s train is increasing

   e) place(s) where the speed of Valravn is nearly constant

   f) place(s) where a large amount of power is being used to move the Valravn train

   g) Middle School challenge: which of the numbered places above are places where the riders would feel as if they are making a hard turn to the left or right?

   h) Middle School challenge: if the Valravn train is climbing the lift hill (location #2) with a constant speed, are all of the forces on the train balanced?

Valravn

1. On Valravn, there are two major portions of the ride in which energy is transferred between the train and the ride's mechanical systems. One is the during the lift, and the other is during braking. For each of the concepts or devices below, choose whether the concept applies to the lift, the braking systems, both, or neither.

   a) tension (as in a cable or chain pulling an object) ______

   b) friction (as in converting kinetic energy into heat) ______

   c) electric motor (converting electrical energy into kinetic energy) ______

2. Name the places or devices on Valravn where the following machines are put to use. Also identify whether these machines are examples of simple machines, or compound machines.

   a) wheel and axle ______

   b) pulley or gear ______

   c) inclined plane ______

   d) combination of simple machines ______

3. Using the ride data given, determine the average speed of Valravn during the ride.

______

4. Explain the difference between average speed, and maximum speed.

______

______

5. Draw and label an arrow on the Valravn track diagram that shows where Valravn is at its maximum speed.

6. How many trains would have to be dispatched in one hour to meet the ride capacity that is given for Valravn?

______

7. How often a train must be dispatched on Valravn in order for the ride capacity to be met? Give your answer in units of seconds.

______

Wicked Twister

Ride data available at Wicked Twister entrance.

- Height:
- Speed:

1. Observe Wicked Twister in operation from a few different vantage points. One good point to watch from would be the area between the Giant Wheel and the long straightaway where the Wicked Twister train heads forward out of its station Draw a nice sketch of the side view of Wicked Twister. Read the following questions, and think about them while you take a ride on Wicked Twister. Then come back and answer the questions.

2. Label the following points on your sketch:
   a) Point where the train has the highest kinetic energy when it is going forward
   b) Point where the train has the highest kinetic energy when it is going backward
   c) Points where the train has the highest potential energy
   d) Areas of the ride where the normal force between the seat bottom and your body is approximately equal to your actual weight.
   e) Areas of the ride where you would be likely to experience significant centripetal acceleration
   f) Areas of the ride where you would experience a sensation similar to free fall
   g) Locations on the ride, and times during the ride, when the force between your body and the seat back is the largest, and why.
   h) Locations on the ride where the kinetic energy of the train would include both a linear part, and rotational kinetic energy (e.g. energy associated with the train rotating approximately around its own center of mass).

3. If the low point of the ride is 6' off the ground, find the approximate height of the center of mass of the train when the train speed is 50 mph, assuming no friction or air drag.

4. Discuss how the shape, and especially distribution of mass, would affect the translational speed of the train as it enters a part of the track that makes it rotate around itself. Do you think this effect will be greatest on Wicked Twister, Raptor, or on Gatekeeper? Ride each one, and compare.

Witches' Wheel

Stand on the midway in the general area between Joe Cool's Corner Store and the exit of the Witches' Wheel, so that you can observe the operation of the Witches' Wheel from the side. From this vantage point you will see that the ride is pushed up from a horizontal position to nearly vertical by the action of a large device called a cylinder. The cylinder is attached to the center of the ride support structure by a shiny silver colored par called the piston rod, or rod, which extends out from the cylinder body. The rod is the moveable part that exerts the force on the ride support structure that lifts it up. It is moved by fluid (hydraulic oil) that is forced into the cylinder under pressure.

1. Draw a side view sketch of the ride, depicting it when it is part way up. Include the cylinder. Indicate and label the following parts of the ride in terms of its operation as a lever:

   a) Fulcrum
   b) Effort (or applied force)
   c) Resistance (or load)

   Note what kind of lever system this ride is. ______________________________

2. Does this kind of lever system multiply force, speed, or both? ________________

3. This problem requires you to ride Witches' Wheel and make observations. Read the questions below, then while riding, listen closely to the sounds you hear. Pay specific attention to the sound of the motor and hydraulic pump as you ride. After your ride, use the space below to write down your observations and answer the questions.

   a) At which point on the ride is the noise of the motor at its highest pitch?

   ____

   b) At which point on the ride did the motor make the lowest pitch noise?

   ____

   c) What is the scientific name of this phenomenon?

   ____

Inequalities of Ride Height Requirement

Examples:

Blue Streak	**x ≥ 48 inches** *(The height requirement for Blue Streak is greater than or equal to 48 inches)*
MAVERICK	**52 inches ≤ x ≤ 78 inches**

Now You Try:

WINDSEEKER	
maXair	
Gemini	
ROUGAROU™	
Ocean Motion	

Transportation

- **One bus holds 52 students**
- **Cedar Point is open for 150 days**

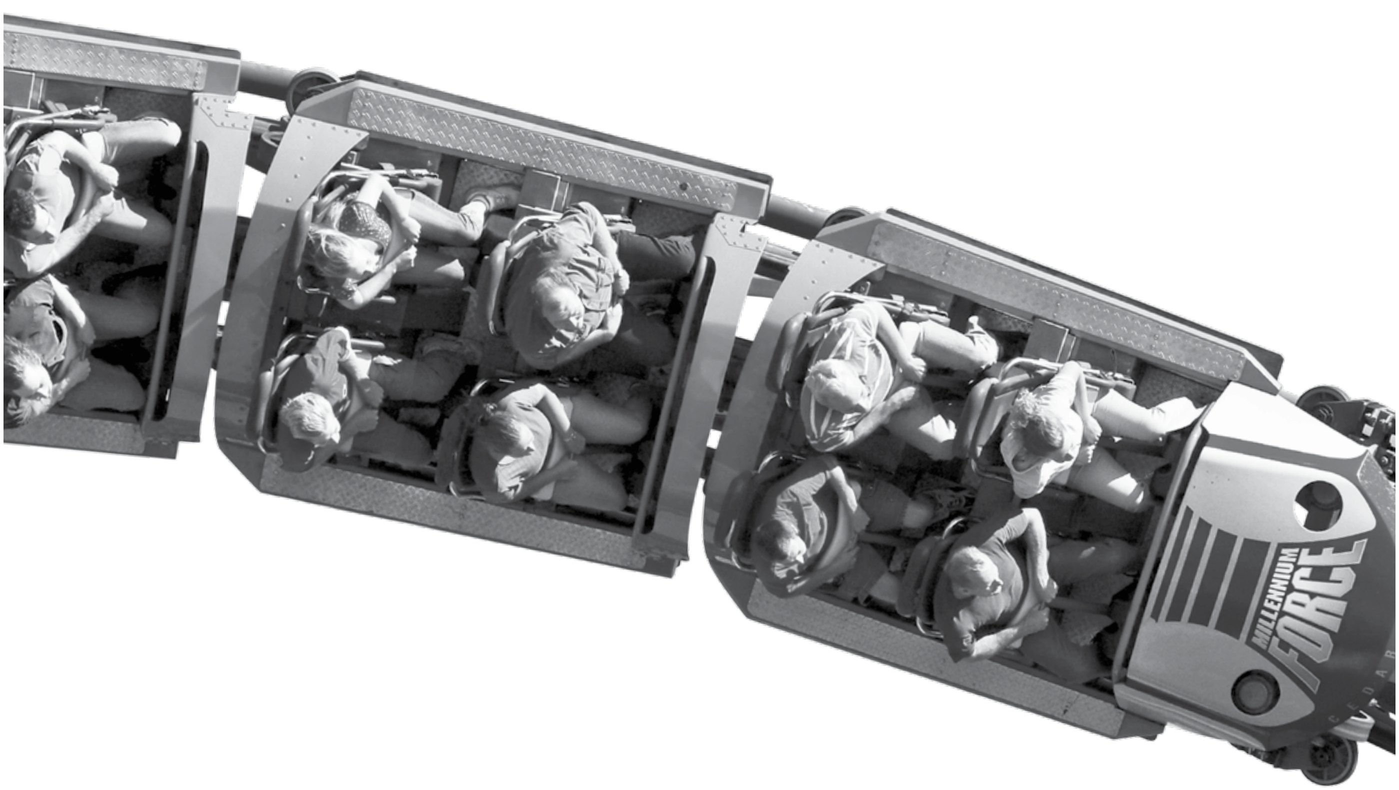
1. If 3,140,000 guests travel to Cedar Point in one year, on average how many guests come to Cedar Point per day?

2. If there are 152 students traveling to Cedar Point on a bus, how many busses would they need to take?

3. If there are 200 students traveling to Cedar Point on a bus, how many busses would they need to take?

4. If there are 3,140,000 guests traveling to Cedar Point on a bus, how many busses would they need to take?

5. If each guest would spend on average $15. How much money would that generate?



Concession Stand

Fill out the price per item. Please circle the best unit price.

Toft's Ice Cream	Price	Unit Price
1 scoop		
2 scoops		
Coca-Cola Soft Drink	**Price**	**Unit Price**
Regular 20oz		
Large 32oz		

Directions: Please fill in 5 items that you would buy and their prices.
Figure out the total price including tax. Items DO NOT have to be purchased.

Item	Price
1.	
2.	
3.	
4.	
5.	
Total cost of all items	
Tax *(6.75%)*	
Total cost after tax	

Passenger Capacity

Ride	Estimated Riders Per Hour	Number of Trains and Passengers per Train	How many times does each train go though each hour
Top Thrill Dragster	1,500	6 Trains, 18 Riders per Train	6 Trains x 18 Passengers = 108 People per Rotation 1,500/108 = 13.8 times Each Train Goes By Approximately 13-14 times per Hour
Iron Dragon	2,000	3 Trains, 28 Riders per Train	
Millennium Force®	1,600	3 Trains, 26 Riders per Train	
Raptor® Rules the Sky	1,800	3 Trains, 32 Riders per Train	
Wicked Twister	1,000	1 Trains, 32 Riders per Train	
GateKeeper®	1,710	3 Trains, 32 Riders per Train	

Kettle Corn

There is nothing better than fresh kettle corn, especially on a fun day of roller coasters! Let's discuss how kettle corn is made. Step one is to add sugar to the large iron kettle, which caramelizes. Step two is to add popcorn kernels. Popcorn kernels contain a hard shell, starchy interior, and moisture. As popcorn kernels are heated, typically in oil, they pop into a white fluffy edible snack. The following questions will guide you through understanding what happens inside the popcorn kernel as it is heated to turn a hard popcorn kernel into something wonderful.

Important Conversion Factors and Equations:

- Molecular weight of water = 18.016 g/mol
- 1 inch = 2.54 cm
- 1 mL = 1 cm3
- 1 cup = 236 mL

$PV = nRT$ $\quad \frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad °C = \frac{5}{9}(°F - 32)$

$V = \frac{4}{3}\pi r^3$ $\quad A = \pi r^2$ $\quad °F = \frac{9}{5}°C + 32$

$K = °C + 273$

Caramelization process: Sucrose undergoes a pyrolysis process (burning without oxygen in the reaction) at approximately 340°F. The first step in this process is the thermal decomposition of sucrose into fructose and glucose. Fructose and glucose further decompose and recombine to make a variety of molecules that ultimately yield the color and flavor of caramelized sugar.

1. Is this process a physical or a chemical change? ____________________

2. Calculate the temperature of caramelization in degrees Celsius and in Kelvin. ____________________

Popping Process: As described above, popcorn kernels contain moisture inside their hull, or shell. To understand why popcorn kernels pop, we first need to make sure we understand what happens to water when it is heated.

3. What phase is water in at room temperature? ________________________

4. What phase does water become when heated above 100°C? _______________________

5. This phase change has a special name. What is it? ______________________

6. What happens to the volume of water when this phase change occurs? _________________

7. Is this phase change a physical or a chemical change? ____________________

8. Initially, due to the hard shell, the volume change cannot occur immediately. Based on Gay-Lussac's gas law relating temperature and pressure, if the volume is held constant as the temperature is elevated, what happens to the pressure? Does it increase, decrease, or stay the same? _________________

9. Given that each corn kernel has approximately 13.5% moisture, calculate the mass of water in each kernel. ____________________

Note: Caramel is used for things like caramel apples, and processes like these can be connected to other candies and foods; e.g. "hard crack" vs. soft carmel, etc.

Kettle Corn

1. 100 kernels of corn were weighed and found to have a mass of 18.04 g. What is the average mass of a single kernel of popcorn?

____

2. In another experiment, the volume of the popcorn kernels was determined through water displacement. Using a 10 mL graduated cylinder, the initial volume of water was set at 5.00 mL. 20 popcorn kernels were added and the volume increased to 7.65 mL. What is the average volume of each popcorn kernel? ___________________

3. Now let's compare the density of unpopped popcorn, plain popped popcorn, and kettle corn. Using the data above for popcorn kernels, calculate the density of unpopped corn in g/cm3. ________________________

Plain popcorn was also analyzed in the lab. A half a cup of popcorn weighed 7 g. Calculate the density of plain popcorn. The data for kettle corn was collected a little differently. A heap of kettle corn was shaped roughly into a hot dog shape with a length of 24 inches and a 2 inch radius. To calculate the volume, we need to do a little geometry. If you were to cut off the ends of our kettle corn "hot dog" and stick them together, you would be left with a sphere with a radius of 2 inches and a cylinder with a length of 24 inches and a 2 inch radius.

4. Calculate the volume of the sphere in cm3. ________________________

5. Calculate the volume of the cylinder in cm3. ________________________

6. What is the estimated total volume of a bag of kettle corn? ________________________

7. The mass of this "heap" of kettle corn was 475 g. Was is the approximate density of kettle corn? ________________________

8. Summary (Fill in the blanks)

So you have learned that popping corn involves the ___________ of water in a confined space. This results in a dramatic ___________ in pressure causing the shell to rupture. You have also learned about the first step in the caramelization process. This is a ___________ change because the bond to the central oxygen in sucrose is bro-ken, resulting in two smaller molecules, ___________ and ___________.

You also calculated the density of popcorn. The density of unpopped popcorn kernels was _________ g/cm3 while the density of plain popcorn was _________ g/cm3. The reduction of density is primarily a result of the ____________________________________. The density of the kettle corn is _________ g/cm3. The increase in density as compared to plain popcorn is largely due to the ____.

Cotton Candy

Cotton candy is produced by a special machine that first melts the sugar at 367 °F. The melted sugar is then spun into thin threads which cool into solid sugar strands. Food coloring can be added to the melted sugar.

Important Conversion Factors and Equations:

- 1 lb = 16 oz. = 454 g
- 1 inch = 2.54 cm
- 1 gallon = 3.785 L

1. Is the process of making cotton candy a physical or chemical change?____________________

2. Why is cotton candy cool immediately after removing it from the machine?

____

____

A bag of cotton candy was analyzed in the lab. The lab determined that the bag weighed 6.83 oz. Carefully, with minimal compression, the cotton candy was shaped into the form of a hot dog with a length of 11.5 inches and a 2 inch radius.

3. What is the mass of cotton candy in grams? ___________________

To calculate the volume, we need to do a little geometry. If you were to cut off the ends of our cotton candy "hot dog" and stick them together, you would be left with a sphere with a radius of 2 inches and a cylinder with a length of 11.5 inches and a 2 inch radius.

4. Calculate the volume of the sphere in cm3. ______________________

5. Calculate the volume of the cylinder in cm3. _____________________

6. What is the estimated total volume of a bag of cotton candy? ________________

7. From the mass and volume, determine the density of cotton candy. ___________________

Note: It might be interesting to have students watch cotton candy being made.

Cotton Candy

A 5 lb bag of granular sugar (full bag of sugar available at any grocery store) has a volume of approximately 0.38 gallons.

1. Calculate the mass of the bag of sugar in grams. ______________________

2. Calculate the volume of the bag of sugar in cm3. ______________________

3. Calculate the density of granular sugar. ______________________

4. If you were to prepare similarly sized bags of cotton candy from your 5 lb bag of grocery store sugar, how many bags of cotton candy could you produce for you and your friends? ______________________

5. According to the packaging, a 12 oz. serving of Coke contains 39 g of sugar. If you used the sugar content of Coke, how many cans of Coke would be required to make a single bag of cotton candy? ______________________

6. Summary (Fill in the blanks)

So you have examined cotton candy. The candy making process begins with the _____________ of sucrose and concludes with collecting the spun candy threads. The density of granular sugar was determines to be _________ g/cm3 and the density of cotton candy _____________ to ________ g/cm3. There is an amazing amount of sugar in each bag of cotton candy. Using a 5 lb bag of grocery store sugar you can only make _______ full bags of cotton candy and it would take the sugar content of ______ cans of Coke to make a single bag. Yikes! Don't eat that all in one sitting. . .

Food Section Citations

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Lighting & Power

As you walk along the main midway, you'll notice that many trees and structures are decorated with miniature lights. Look around, especially near Cadillac cars and the Pagoda building. These lights are constructed using light emitting diodes (LEDs). They are very energy efficient.

One common, newer lighting technology is to make a small bulb that contains three LEDs - one red, one green, and one blue - in a single package, but with individual control over the colors. These bulbs can be organized in strands, such as those on the ceiling of the "tunnel" that goes under the Millennium Force track along Frontier Trail. The envelope of the bulb combines the light output of the LEDs, and the color you perceive is the composite of the individual components. The idea of color mixing is also the basis of how the lights on the Giant Wheel work.

1. What LEDs would you illuminate to generate the various colors indicated below?

   Red:____________________ Yellow:________________________ Cyan:_____________________

Steam emanating from the Davis-Besse Nuclear Power Station can be seen from Cedar Point. Davis-Besse uses Nuclear Energy to produce electricity for much of North Western Ohio, including Cedar Point

2. What are three subatomic particles that make up an atom?

____

3. What are their relative masses?

____

4. Draw and label a general model of an atom.

5. What makes one atom of an element different than another atom of a different element?

____

____

6. Nuclear Power Plants utilize atoms of a particular element that undergoes nuclear decay. What causes an atom to decay?

____

____

7. When an atom of an element undergoes nuclear decay it emits radiation. What is radiation?

____

____

This decay process releases energy as heat. The power plant uses this heat energy to heat up water to boiling. The steam is then used to turn generators that produce electrical energy. The electricity is then fed into the electrical grid - a system of interconnecting wires and controls, that makes the electricity available to the people that need it.

Rollercoaster Steel

Steel is a metal that is used to build with. Steel is called an alloy because it's composed of carbon, iron and other elements that help give it strength. Therefore, there are different types of steel. Steel has grades determined by the SAE organization. One set of steel grades is commonly referred to as "structural steel", and is used for structures such as roller coasters because it is very strong. Still, structural steel needs protection from the weather, as the next set of problems illustrates.

The conversion of Iron to rust is a four part reaction:

$$2Fe(s) + 2H_2O(l) + O_2(g) \longrightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$$

1. Overall, is the iron changed physically or chemically? ____________________

2. What would happen if the tracks and steel structures were not painted?

____

____

3. Steel is is a combination of iron and a variety of other elements, with the exact composition depending on the type of steel needed. Can you name each of the elements in the following list?

   a) C
   b) Mn
   c) P
   d) S
   e) Si
   f) Cr
   g) Ni
   h) N
   i) Fe

4. Conclusion (Fill in the Blanks)

So, steel is a metal ________, meaning that it is composed of different _________. The grade of steel matters because the grade reflects properties such as _____________. Rust is a ___________ part reaction in which a ____________ change occurs. Rust is a corrosive process and can damage structures, so _______ is used to protect the steel.