Student Days

at Scarborough Renaissance Festival®

Science

Scarborough Curriculum Guide Outline by Subject For Teachers' Use

Scarborough Renaissance Festival®

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Science

Objectives: Students will-

- Demonstrate ways objects move, and how fast they move.
- Explore force and motion related to potential kinetic energy.
- Construct a set of diagrams illustrating the mechanics of the block printing press.
- Analyze relationships between chemical and physical changes and properties.
- Identify native plants using a dichotomous key.
- Research and describe the contributions of early scientists to our changing understanding of astronomy, including Ptolemy, Copernicus, Tycho Brahe, Johannes Kepler and Galileo.
- Trace the historical development of the Periodic Table and apply its predictive power to a hypothetical circumstance.
- Explore the significance of salt during the Renaissance for food preservation.
- Describe the importance of inventions and scientists from the Renaissance period.

Elementary 1st – 5th

TEKS: 1. 6d; 4. 10b

Middle School 6th – 8th

TEKS: 6. 8; 7. 7; 8. 6

High School 9th – 12th

TEKS: 1-4 Chemistry 4, Chemistry 1-3; Environmental Systems 4.a; Astronomy 4.b

Sample Lesson:
- Salt
- Crow's Nest
- Sea Dragon

Resources: www.saltworks.us

Salt

Materials:

- Attached none

Discussion:

- The following activity is meant to be flexible in duration and ability level. Use all, some, or none of the format presented depending on your students' depth of study. Have students learn about salt as a food preserver and why it was used before refrigeration was invented. Encourage the students to seek out foods made from or preserved with salt. Poll students while on the bus back to campus to generate a list of foods found at the Festival made with or preserved by salt. Hint – pickles, jerky, sauerkraut.

Challenge:

- Have students learn where salt comes from and the different ways it is mined.
- Have students brine some vegetables.

Here is some background information for you to use.

Since ancient times, salt has been used for both seasoning and for preserving food. It has been such a necessary element that it was, in fact even, traded in place of money at times.

During the Middle Ages other spices were brought to Europe like pepper and cinnamon. It was this new fascination with seasonings that helped to spur exploration of spice trade routes.

Crow's Nest

(Middle, High School)

Proficiency Outcomes: Science

Grade 9

- Apply the concept of energy transformations in mechanical systems.
- Apply the concept of force and mass to predict the motion of objects.

Grade 12

- Trace energy transformations, and/or apply the principles of mass/energy conservation to physical systems.
- Use fundamental forces to explain and make predictions about motions and changes in systems.

Discussion:

Energy is defined as the ability to do work. There are many types of energy, including kinetic, potential, electrical, heat, nuclear energy and more. For this ride we will be primarily concerned with these types of energy: *gravitational potential energy* and *kinetic energy*. An object can have energy because of its position or because of how fast it is traveling (speed or velocity).

The Law of Conservation of Energy states that the amount of energy that is put into the system (in this case the ride is the system) is exactly what can be taken out of the system. The enjoyment of movement is received because of the energy (work) someone else put into it. Energy is put into the system (by the ride-laborer) and a gravitational potential energy is established. Once the ride-laborer lets go of the ride, the gravitational potential energy is converted into mostly kinetic energy. An undetectable amount of energy will be lost in other areas.
NOTE - You will not be able to calculate every area that will experience a loss of energy. The friction in the ropes and the pole and the air resistance from the basket and people are good examples. You may choose to give an allowance for that loss.

Teachers note - Ask students to come up with other possibilities of loss of energy. Hooks and ropes tied at the top and at the bottom on the basket, air resistance of ropes, basket, and people are some examples of loss of energy. Wind plays a role, if it is strong enough. The ride consists of a pole with eight ropes tied to a basket (see spec. on subsequent page). As the ride-laborer turns the basket around the pole, the ropes wrap around the pole. Once the ride is let go the basket turns around the pole as the ropes unwind.

Energy is neither created nor destroyed. It merely changes form.

For example, after all of the ride-laborers put an amount of **work** (**force** x **distance**) into the system it would then have a certain amount of potential energy due to the gravitational force pulling everything towards the center of the earth. Before the ride-laborers release the ride it has only potential energy and no kinetic energy. Why? The kinetic energy is zero because it is not moving (velocity = 0). Zero multiplied by anything is zero. Therefore, kinetic energy is zero just before the ride-laborers let it go. Halfway through its descent, however, there is 50% potential and 50% kinetic energy. What the ride had in potential energy is being turned into kinetic energy. Evidence of this exists as you observe the ride going faster. Once the original height (the ride at rest "h") is achieved there is 0% potential energy. However, the kinetic energy it achieved by losing potential energy. Kinetic energy transferred back into potential energy (minus the loss of heat energy due to friction) on the way back up. The height that the ride will achieve on the second round will be less than the original height because of the loss of energy due to frictional forces.

Crow's Nest Continued

Friction Activity - Have students rub their hands together as fast as they can. See who thinks they can get their hands the warmest.

The gravitational potential energy depends on three things: the total **mass** of the object, the value of **"g"** (on earth "g" is 9.8 meters per second squared) and the height the object is from the surface (the ground). Remember also, that "g" is going to stay the same whether we are talking about you or someone else on earth no matter how large their mass is. What is the reason for this phenomenon? The gravitational force is dependent upon your mass and the mass of the earth; the earth's mass is so large that our mass is insignificant. It would be comparable to someone giving you a paper clip while you are on the bathroom scale. It will make an insignificant difference.

Ride Specifications:

Ride height (h) = 6 ft = 2m	weight of basket alone = 680 kg
Width of base to ropes (b) = 16 ft	gravitational force (g) = 9.8 m/s2

Write your answers in complete sentences.

1. What happens to the distance between the basket and the ground ("d") as the eight ropes wrap around the pole? (The distance increases.)

2. What is causing the ropes to wrap around the pole? (the work put in [input] by the ride-laborer)

3. What happens to the distance between the basket and the ground "d" as the ropes unwind? (The distance decreases.)

4. What is causing the ropes to unwind? (force of gravity - Gravitational Potential Energy)

5. Suppose the ride contains 14 people that have an average weight of 115 kg. The potential energy can be determined if you know the total weight of people and basket at the end of the ropes. Determine the total weight of the ride. {(115 kg x 14) + 680 kg = 2290 kg

6. Calculate the amount of gravitational potential energy established by the ride-laborers just before they let go.
   m = 2290 kg g = 9.8 m/s2 h = 6 ft = 2 m

   P.E. = mgh = 2290 kg (9.8 m/s2) (2 m) = 4488.4 kgm^2/s^2 = 4488.4 Joules

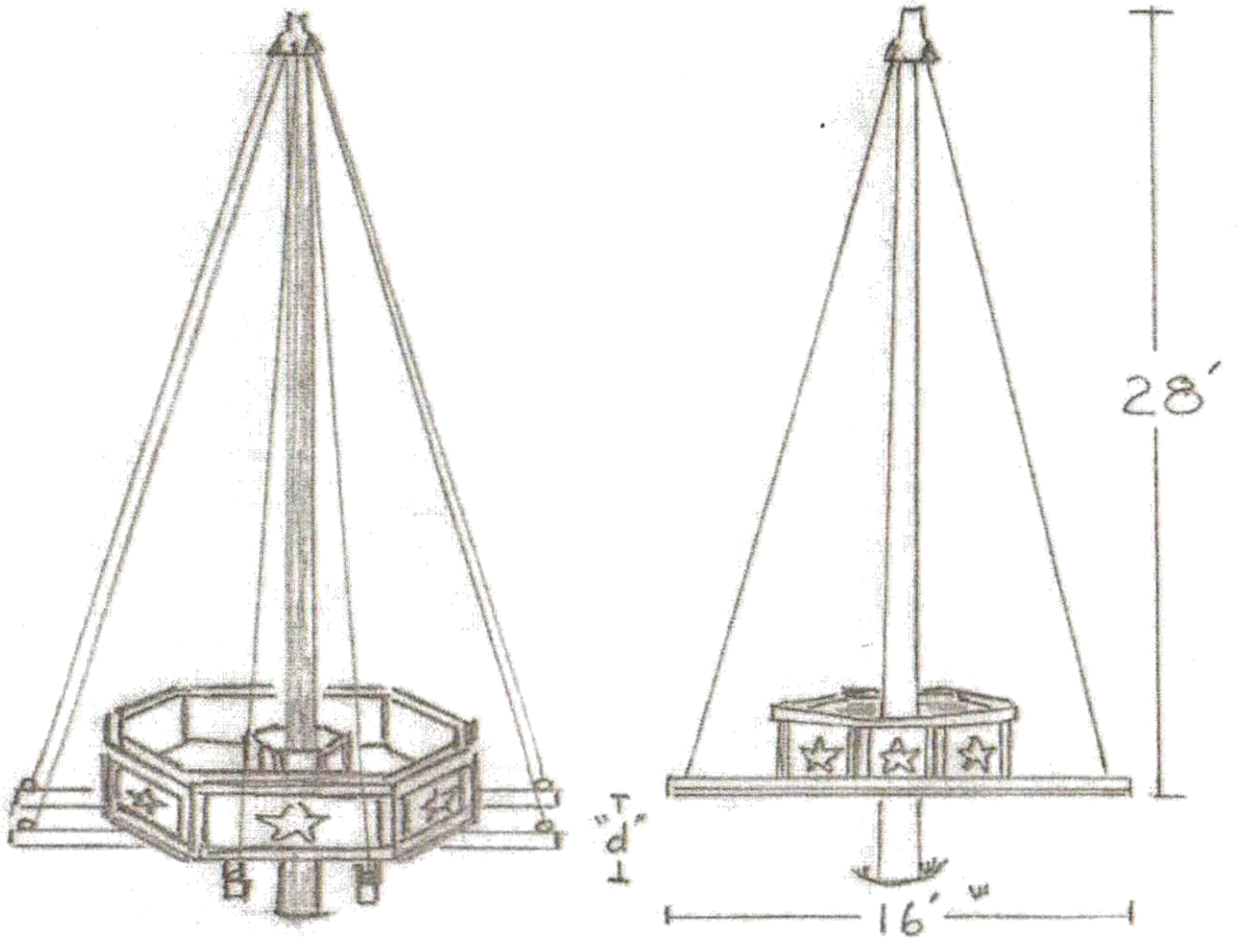
7. Is it possible to determine how fast you would be going at this point in the ride? (yes) Explain. See answer below

8. Using the Kinetic Energy equation, solve for "v", assuming the loss of energy in other areas is small.

   K.E. = $1/2\ mv^2 \rightarrow 2(KE) / M = v2 \rightarrow \sqrt{2(KE)/M} = \sqrt{V}\ 2 = v$

9. Assuming friction is enough to be insignificant, and based on the Law of Conservation of Energy, what would the kinetic energy be just as the basket reaches the original height (before the ride begins and while the basket is at rest)? All of the potential energy is converted to kinetic energy (since friction is insignificant). Using the formula in question 8 the numerical answer is 13 m/s or 43 ft/s if you are using the English system. I would recommend all formulas use the Standard International Units SI).

10. Why does the ride go back and forth a few times before it comes to rest? (Hint - it involves a law of conservation.) (Conservation of Energy, watch closely and you will see that the ropes wrap up the pole converting kinetic energy to potential energy and momentarily the ride's speed will be zero. If all frictional forces could be eliminated, then the ride would continue going back and forth forever.


"d"
28'
16'

Sea Dragon

(Middle, High School)

Proficiency Outcomes: Science

Grade 9

- Apply the concept of energy transformations in mechanical systems.
- Apply the concept of force and mass to predict the motion of objects.

Grade 12

- Trace energy transformations, and/or apply the principles of mass/energy conservation to physical systems.
- Use fundamental forces to explain and make predictions about motions and changes in systems.

Discussion:

Anything that is in motion has kinetic energy. The Law of Conservation of Energy states that energy is neither created nor destroyed but merely changes form. When the dragon is pushed by the ride-laborer, work is put into the system and potential energy is established. The amount of potential energy is determined by the height the dragon is raised from the rest position, the mass of the dragon and riders and the gravitational force of the planet that the ride is on. More information can be found at the beginning of this chapter.

In a perfect pendulum (no friction) the ride would continue to go back and forth and always reach the same height on both sides. Unfortunately, we live in a world with a frictional force and therefore must experience less time riding rides and more time adding things into an equation. When the ride-laborer pushes the ride as high as he possibly can, "h" can be determined. Once the (gravitational) potential energy is known, the velocity of the system (ride) in the middle of its swing (the resting position at the beginning of the ride referred to as the equilibrium point) can be calculated. This means that as the swing goes back and forth it passes through the point where the ride was at rest when the riders were loaded on. At this point we will have all kinetic energy and zero potential energy. That kinetic energy is what allows the ride to continue on to the upswing. As we discovered in the Crow's Nest, the kinetic energy is converted to potential energy. With each back and forth motion the ride loses some energy in the form of heat due to friction and will bring the riders up to the highest point possible (which will not be as high as it was in the previous back and forth motion).

The ride-laborer keeps the ride going by adding additional energy as the swing passes by. This additional force involves other concepts such as momentum and vectors, which will be developed in the future. Feel free to explore the concepts with your higher level students.

Now back to the pendulum concept. There are various types of pendulums. This ride is an example of a pendulum (albeit not a perfect or simple one) as well as a board swinging from one end and a tire swinging on a rope etc. You may want students to list other examples. In a simple pendulum an object (the pendulum "bob") swings freely on a string. The string must be able to be considered massless in comparison to the mass of the bob. The **period** of a pendulum is the time taken (in seconds) to complete one back-and-forth swing. To a high degree of precision, the period depends only upon the length of the pendulum and not upon the angle of swing. (This is true as long as the angle of swing does not exceed 5 or 6 degrees. As the angle - the amplitude- gets larger, the period does also, but the effect is hardly measurable unless large angles are used.) The longer the length of a pendulum; the longer its period. In this ride large angles are being used. In addition, the pendulum is not a simple one. However, students will be able to relate the ride to pendulum motion. You may want to demonstrate a simple pendulum to students before the field trip.

Sea Dragon Continued

The equation for the period of a simple machine is as follows:

$t = 2\pi$

Where t is the period, l is the length of the pendulum (measured to the center of mass of the pendulum bob), and g is the force (acceleration) of gravity.

Teachers notes - Investigating Pendulums
In a pendulum, the mass of the ball does not affect the period.

Ride Specifications:

Length of pendulum ≅ 5 m gravity (g) = $9.8\ m/s^2$
Mass of dragon 430 kg height = 9 m

Write your answers using complete sentences.

1. Suppose the ride holds 6 people with an average weight of 115 kg each, what is the mass of the ride? {(115 kg x 6) + 430 kg = 1120 kg}

2. Calculate the gravitational potential energy established by the ride-laborer just before he lets go. P.E. = mgh = 1120kg x $9.8\ m/s^2$ x 5 m = 98,784 J

3. Determine the velocity (speed with direction) of the ride as it reaches the equilibrium point.

   {K.E. = 1/2 mv^2 Ü **= V^2 Ü** $\sqrt{2(KE)/M}$ **=** $\sqrt{V^2}$ **= V }**

4. Why is the velocity the same in this ride as it was for the Crow's Nest? (Because the riders reach the same height and because the mass cancels out of the equation.

5. Determine the period (time it takes to go back and forth) of this ride?

   ($t = 2\pi = 4.5$ s)

6. Using your knowledge of a pendulum explain how you could make the ride last twice as long? (Since mass is not a factor in the period of a pendulum, the only way to make the ride last twice as long is to increase the length of the ropes by a factor of four - remember that the square root of the length is being taken.

Suggested Projects and Classroom Activities

Complementing Contest:
Hold a complimenting contest in your classroom. Students will create their own compliments, and then select an opponent. The more elaborate the compliment, the better, and the last person to run out of compliments wins. (The best formula for creating a renaissance-style compliment is to compare your subject to beautiful things. For example: "Your eyes are more radiant than a thousand stars on a crisp, clear night." One of the richest sources for inspiration is Shakespeare's Romeo and Juliet.)

Build a Castle:
Design and build a model of a castle. During Henry VIII's reign, he built the castles of Deal, St. Mawes, Walmer, Sandown, Pendennis and rebuilt Dartmouth. However, due to the utilization of gunpowder and cannons during this period, the design of castles changed from that of medieval castles. Tudor castles were circular or semicircular structures made up of several circular sections. Medieval castles, for the most part, were square or rectangular. Rounded walls gave Tudor castles a more deflective surface against cannon fire and a better field of fire for their own guns and cannons inside the castle. Tudor castles also had a lower profile (less of a target for cannons) and thick walls.

Royal Feast:
Research and create a menu for a feast. Remember that England is an island. There were plenty of sheep, but spices were quite a luxury because of their expense.

Greetings:
Have your class practice greeting one another in the 16th Century style (see "Customs and Mannerisms" herein).

Present a Petition:
Elect your own Parliament and have its members present a petition to Henry VIII.

Historical Writing:
Write a letter or journal entry from the point of view of a historical figure. For example: a letter from Wolsey to Henry VIII regarding Parliament's refusal to grant him funding for a war, or a journal entry from Anne Boleyn concerning her long awaited marriage to Henry VIII. Be creative! Pick any one or make one up but be sure the letter or journal entry deals with a specific event.

Role Playing:
Act out a meeting between Henry VIII and Pope Clement VII in regard to Henry's divorce from Catherine of Aragon, or between Henry VIII and one of his advisors regarding a matter of national concern.

Create a Newspaper:
Although there were no newspapers in Renaissance England, create one for your class and include stories regarding the King's progress, Parliament's activities, and various military and religious happenings. Look at your local newspaper to gain a better understanding of story placement, writing style, and use of advertisements.

Obituaries:
Write an obituary notice for King Henry VIII, Catherine of Aragon, Anne Boleyn or another important figure of the day. Examine the obituary section in your local newspaper to learn writing style and pertinent information.

A Renaissance Christmas:
Stage a Christmas celebration in Renaissance England. What would be on the menu? What songs would be sung? Was there a Santa Claus, etc.?

Panel Discussion:
Create a panel discussion or debate regarding an unpopular policy of national or domestic concern.

Timelines:
Create a timeline based on the information presented herein. Remember to highlight the important dates in Henry VIII's reign.

Calligraphy & Illumination:
Study some different calligraphic alphabets, and then try to learn one. Copy or write a paragraph in your new handwriting. Have students look at examples of manuscript illumination and have them illuminate a bookmark using their own initials.

Coat of Arms:
Have students create a Coat of Arms. Many coats of arms contained lions, eagles, and mythical beasts. An excellent resource is *A Complete Guide to Heraldry* by A.C. Fox-Davies.

Translating Conversation:
As an exercise, try to translate an ordinary 21st century conversation into Old English.

Old English	**21st Century**
Faith, Jack, where hast thou been?	Wow, Jack, where have you been?
Thou wast to have been up betimes!	I thought you were gonna get up early!
Aye, even so. My good grey mare threw a shoe upon the road; naught could I do but lead her to the smithy in Stratford, some seven miles off.	Yeah, but I had a flat tire and no spare. I had to hitchhike to World of Auto Parts.
By St. Christopher, t'is ill luck	Yeah, bummer
Too true, alack. Hast supped? I fear me thy trenchers be bare	You're telling me. Is there any food left? I bet you guys ate it all.
Nay, in good sooth; we kept a cold partridge wing and a tankard of cider against thou shouldst arrive.	No, as a matter of fact we saved you some pizza and a Pepsi.