student activity

WHITEWATER WORLD
BY DREAMWORLD

Science Education Program

Name: _____

Teacher: _____

School: _____

Race through an exciting journey of energy changes as you discover the secrets of the operation of the world's latest innovation in waterslide technology. You'll learn how potential energy is transformed into kinetic energy as you plummet from an 18m tower and then experience the force of electromagnetism as you're rocketed up five vertical rises. This activity unlocks the magic of the linear induction motor – you can't see it, you can't hear it, it has no moving parts and it never touches your Rocket Raft – yet it will shoot you up an incline at breath-taking speed! This is the ultimate in "electricity meets water science" – and the result has never been more shocking!

Syllabus Outcomes

Years 6 and 7

Energy and Change 4.2 Students collect and present information about the transfer and transformation of energy (including potential and kinetic energy).

Years 8 and 9

Energy and Change 5.2 Students explain how energy is transferred and transformed (including energy transfer by convection and conduction).

Energy and Change D5.5 Students outline the energy changes that occur in simple physical and chemical changes and link their observations to scientific understandings about the conservation of energy.

Year 10

Energy and Change 6.2 Students model and analyse applications of energy transfer and transformation.

Equipment

Student activity sheets, pens/pencils, calculators

Activities with this symbol may be completed while you're having lunch at WhiteWater World, or after you leave WhiteWater World.

Standard Achieved

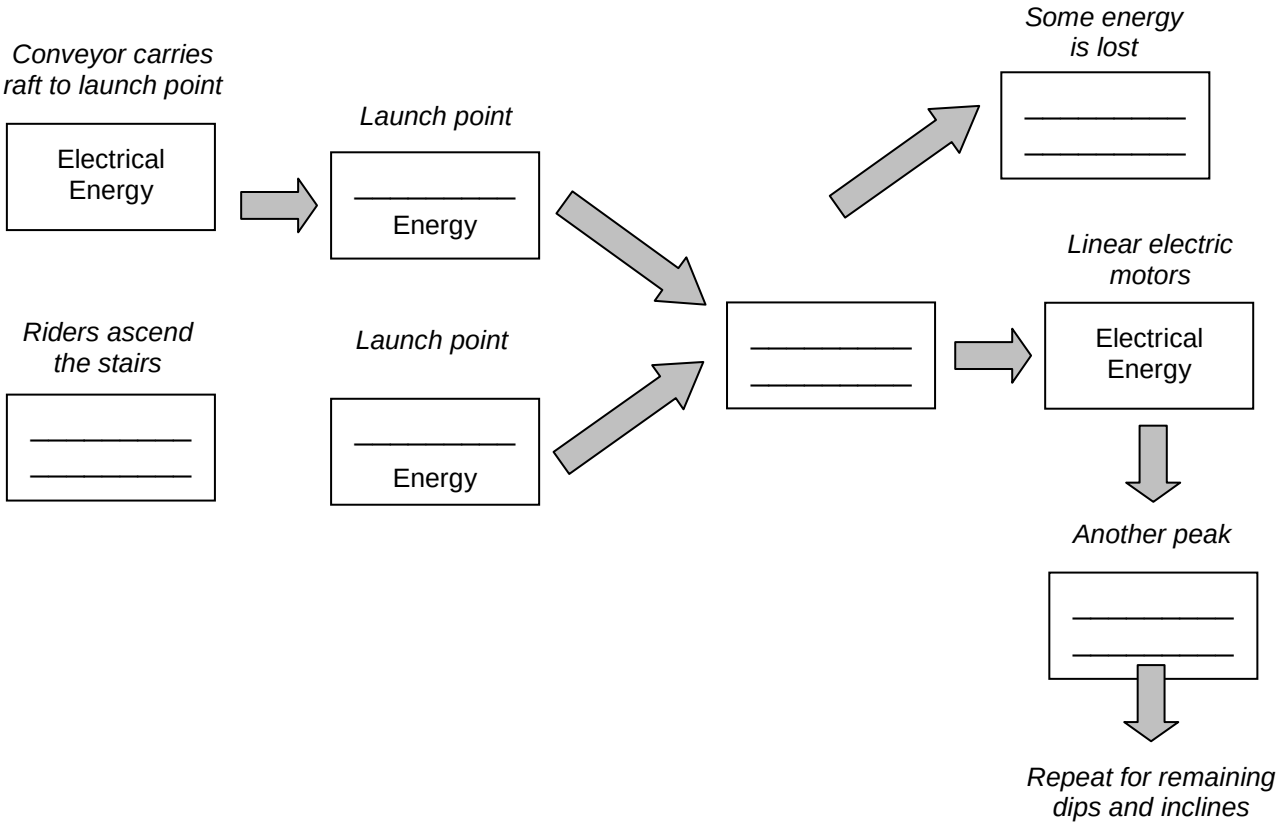
E&C 4.2	E&C 5.2, E&C D5.5	E&C 6.2

Energy Transformations in the Super Tubes Hydrocoaster

Question 1 (Level 4 Outcome)

There are many energy transformations that occur in the Super Tubes Hydrocoaster. Use the following description to assist in completing the energy flow chart below.

Electrical energy powers the conveyor that carries the rafts to the launch point. In this position they possess the maximum potential energy. At the same time that the rafts are ascending, chemical energy in the legs of the riders is carrying them excitedly to the top of the tower. In the raft, potential energy is quickly converted into kinetic energy on the first downward slope. Some of this energy is lost to friction and heat, so the raft needs a helping hand to ascend to the next peak. Electrical energy is converted into kinetic energy as linear electric motors hidden in the track propel the raft up the incline. Kinetic energy is converted to potential energy as it reaches another peak, ready to plummet into the second dip. This process repeats for a total of five dips and four inclines.



Question 2 (At-home Level 4 Extension Outcome)

Pushing the boat out further

Design your own water park ride and create a flow chart like the one above to depict the energy changes that take place at each stage along the ride.

Energy Calculations

Question 3 (Level 5 Outcome)

You burn off energy every time you climb the steps to the top of the Super Tubes Hydrocoaster. But exactly how much do you burn? You can work it out from your mass and the height that you've climbed.

Count the number of steps from the bottom of the steps up to the top of the Super Tubes Hydrocoaster.

Number of steps = _____

The height of each step is about 18cm. Calculate the height that you have reached at the Super Tubes Hydrocoaster launch level. Convert your answer to metres.

_____

_____

_____

_____

Height = _____ m

You also need your mass to calculate your energy._____Your mass = _____ kg

The chemical energy that you burn is equal to the potential energy that you gain in climbing to the top of the stairs. Potential energy is the product of your mass (m), height (h) and the acceleration of gravity (g). That is, $PE = mgh$.

If the acceleration of gravity, g, is 9.8 m/s^2, calculate the potential energy that you have gained, and hence the energy that you have burned. The units for energy are joules, J.

_____

_____

_____

_____

Energy burned = _____ J

Because joules are small units, we often convert energy quantities into kilojoules (kJ), where 1kJ = 1000J.

Convert your answer to kilojoules.

_____

_____

_____

_____

Energy burned = _____ kJ

Two scoops of ice cream contain about 400kJ of energy. How many times would you have to climb the stairs to the top of the Super Tubes Hydrocoaster to work off an ice cream?

_____

_____

_____

Number of ascents to burn off an ice cream = _____

Question 4 (Level 5 Outcome)

You can also use the potential energy formula to calculate the energy of the raft at the top of the tower.

If the raft has a mass of 45kg, calculate the total mass of the raft and three 50kg occupants.

_____

_____

_____

_____

_____

Mass = _____ kg

The height of the launch point above the first dip (h) is 11m and the acceleration of gravity (g) is 9.8m/s^2. Use this information with the mass that you have just calculated to determine the potential energy of the raft.

$PE = mgh$ = _____ = _____ J

Question 5 (Level 6 Outcome)

As the raft descends into the first dip its potential energy is converted into kinetic energy. The *Law of Conservation of Energy* states that energy cannot be created nor destroyed, only converted from one form to another. Hence, the kinetic energy at the bottom of the dip is equal to the potential energy at the top of the peak. You can use the potential energy that you have just calculated to determine the kinetic energy and hence the maximum velocity achieved in the dip.

Kinetic energy is half of the product of mass and the square of velocity. That is, $KE = \frac{1}{2} mv^2$.

Conservation of energy tells us: *KE = PE*

Hence, $PE = \frac{1}{2} mv^2$

Substitute the mass and potential energy calculated in Question 4 into this equation.

_____

Now solve this equation to find the velocity in m/s.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Velocity = _____ m/s

Question 6 (Level 6 Outcome)

The velocity calculated in Question 5 will always be higher than the actual velocity that you achieve in the raft. Explain why this is the case, with reference to conservation of energy.

Question 7 – Optional (Level 6 Extension Outcome)

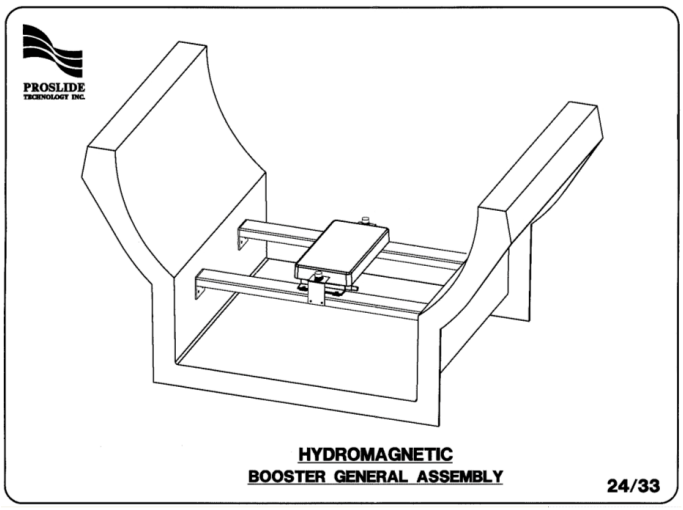
When we equated KE and PE in Question 5, we could have written the formula as $\frac{1}{2}mv^2 = mgh$.

Rearrange this formula to make v the subject. Hence comment on the effect of mass on the maximum velocity achieved in each dip. Will you travel faster with lighter or heavier companions in your raft?

The Linear Induction Motor

The Super Tubes Hydrocoaster is accelerated up its four inclines by means of a linear induction motor system hidden inside the track. You can't see it, you can't hear it and it has no moving parts, but there's no way that you can miss its force as it grabs your raft and whips you up the slope! This is the world's latest innovation in waterslide technology, and the science behind it is quite remarkable.

There are more than 40 "stators" hidden in the track of the Super Tubes Hydrocoaster, visible here during construction. The system is named "Hydromagnetic Booster Technology" by its manufacturer, Proslide Technology Inc.



How it works

A linear electric motor is essentially an electric motor that has been "unrolled" so as to produce a force in a straight line instead of a rotating force. It consists of an array of magnets and a coil of wire which produces a moving magnetic field when electricity is passed through it. When a conductor (such as a plate of metal) is nearby, eddy currents are induced in the plate which produce an opposing magnetic field. The two opposing fields repel each other, and the plate is pushed away from the motor in the direction of the moving magnetic field.

The linear electric motor was designed by Charles Wheatstone in London during the 1840s, but it was not until almost a century later, in 1935, that the first working model was built by German engineer Hermann Kemper. The first full-size working linear motor was built by Eric Laithwaite in London in the late 1940s.

Linear motors can also be found in…

- Maglev trains
- Particle accelerators
- Roller coasters
- Mine lifts
- Sliding doors
- Laser cutters
- Railguns
- Coilguns
- Aircraft launch systems
- And may soon be used for spacecraft launches

The base of each raft in the Super Tubes Hydrocoaster contains a steel plate. As the raft reaches the first stator, the plate activates a sensor which triggers the first stator and powers the raft forward, switching it off after the tail passes. This is repeated over each stator, propelling the raft forward at an ever greater speed!

Question 8 (Level 6 Outcome)

Create a set of cartoon frames or a series of diagrams to show how the Hydromagnetic Booster system works in the Super Tubes Hydrocoaster. Include a caption to explain each frame.