Cycling

Have you ever ridden a bike? Maybe you own one. While the bicycle is used by millions of people around the world as a means of transport, it is also used for recreation, or in sports such as triathlons, track cycling, BMX or mountain bike competitions. Cycling is one of the fastest growing sports in the world and one of the toughest events at the Olympic Games.

Student Background

Cyclists must have incredible levels of fitness and stamina.

Men's Cycling road race – Beijing Olympics 2008 **Guardian**

Cycling is a sport that attracts as much interest in the state-of-the-art bikes as the athletes. Spectators are sometimes kept waiting until the last minute to know what sort of high-tech bike the riders will use.

There are four types of competition for cycling at the Olympic Games – track (in an arena or velodrome), road, mountain bike and BMX (making only its second appearance at the London 2012 Games).

Races include pursuits, time trials, and sprints.

DID YOU KNOW?

Cycling has featured at the Olympics since the first modern Games in 1896. A famous early Olympic cyclist was the Australian Edgar 'Dunc' Gray who won gold at the 1932 Los Angeles Olympics. The Olympic Velodrome in Sydney is named after him.

The following information will help you find out more about bikes in general and racing bikes such as those that will be used in the London 2012 Olympics.

Minerals and metals are essential to the making of a bike, especially a really fast one. Most of the materials used in the bike first started out as rocks in the ground. These rocks contain minerals that can be mined, and then processed into metals. Bikes are made up mostly carbon fibre and metals, as you will soon find out!

Information Sheets

History of Cycling

Interesting facts and pictures about cycling and Australian cyclists

http://www.ausport.gov.au/ais/sports/cycling/home

http://www.shanekelly.net.au/profile/biography/

http://www.cadelevans.com.au/

www.cycling.org.au

Student Activities

Bike Bits(Looks at the use of minerals and metals in everyday bikes)
Balancing Act (Looks at the relationship between properties and uses of materials)
Lean, Mean Cycling Machine (Looks at the special metals in an Olympic racing bike)

Student Activity - Bike Bits

Introduction

All bikes have certain features in common, however not all bikes are exactly the same. You can easily see this by looking at the differences between a BMX and a mountain bike, for example. Bikes are designed so that they can be used for different purposes. An Olympic racing bike has very special features that you wouldn't see on an everyday street bike.

Have you ever stopped to think about the special features of each bike, and what the parts of a bike are made of? When a bike is constructed, many decisions have to be made about what materials to use, as various metals are selected for certain purposes.

For most of the history of road racing, bicycle frames were constructed from steel tubing, and aluminium and titanium alloys were also used successfully in racing bicycles. Racing bicycles in these three materials are still commercially available and are still used by some amateur racing cyclists. However, virtually all professional road racing cyclists now use frames constructed from various carbon fibre composite materials, and a typical modern carbon fibre frame weighs less than 1 kg.

Anna Meares (Aust) wins silver - Olympic Games Beijing 2008
Sydney Morning Herald

INVESTIGATION

In this activity you will compare the parts and designs of various bikes and then look at what materials have been used to make them.

WHAT YOU NEED

A selection of bikes brought into the classroom such as a BMX, a street bike and a mountain bike.

WHAT TO DO

1. Form six groups. Each group will choose and look at one of the following parts on each of the bikes - the pedals, chain, seat, frame, brakes/gears, wheels/tyres.
2. Compare the part on each of the three bikes and decide whether the part is made of metal. These questions will help – is it shiny, does it jingle or ring when hit, does it heat up in strong sunlight, is it prone to rust, is it strong?
3. Record your observations in two tables like the ones below. Each group completes their own bike part table, and then the class can complete the table - Am I Metal?

Bike Part: Pedals

	STREET BIKE	BMX	MOUNTAIN BIKE
Similarities **(Might include size, weight, material s, shape, connection to other parts)**			
Differences			

Am I Metal?

PART	SHINY	JINGLES	HEATS	RUSTS	STRONG
Pedals	✓				
Chain					
Seat					
Frame					
Brakes/Gears					
Wheels/Tyres					

1. What features do all three bikes have in common?
2. Think about the main differences between the bikes. Why do you think these particular features are different? (Hint: what are the uses for the bikes?)
3. Which of the bikes' parts contain metals?
4. Which one of the five characteristics of metals –
    a. is particularly useful in making a bike?
    b. can be a problem?

Student Activity - Balancing Act

Introduction

Metals and other materials are used to make a bike. Several different factors need to be considered when choosing what materials are best for various parts of a bike. One material might be great because it's lightweight, but dangerous because it too easily snaps when put under any strain. Another material might be very strong but too heavy. Like a cyclist on their bike, it's a real balancing act!

Australian Team Pursuit - Beijing Olympic Games 2008 Sydney Morning Herald

INVESTIGATION

This activity looks at the different features of several materials and makes some conclusions about their relative usefulness in constructing a bike. The features are -

- density (affects the weight of a material),
- strength (how much pressure a material can withstand before breaking),
- stiffness (how well the material holds its shape),
- how soft it is, compared to other materials.

WHAT YOU NEED

Samples of wood, **steel** (eg. nail), **aluminium** (eg, soft drink can), carbon fibre (eg. graphite tennis racquet) and nylon.

MATERIAL	DENSITY (g/cm)	RELATIVE STRENGTH	RELATIVE STIFFNESS
Wood	0.5	1	20
Nylon	1.1	0.8	1.5
Carbon-fibre	1.6	18	100
Aluminium	2.7	2	35
Steel	7.8	10	105

Source: 'Physics Matter', England, N. 1995.

QUESTIONS

Examine the samples of wood, steel, aluminium, carbon fibre and nylon and study the table above.

1. What features of nylon make it suitable for racing bike seats and clothing?

_____

2. Look at the characteristics of steel, aluminium and wood and think about which you would choose to make a bike frame.

    a. What two advantages does steel have over wood?

(i)_____ (ii) _____

    b. What two advantages does steel have over aluminium?

(i)_____ (ii)_____

    c. Why is aluminium sometimes mixed (alloyed) with steel to make bike frames?

_____

3. Some racing bikes have solid wheels made from a carbon-fibre composite. Why?

_____

Student Activity - Lean, Mean Cycling Machine

Introduction

If you have a bike it is probably strong but fairly heavy. Try lifting it up steps; it's hard work! An Olympic racing bike, on the other hand, is almost entirely made from **carbon fibre**, which is a type of Fibre Reinforced Plastic (FRP). This includes frames, forks, seat pillars, saddle skins, handlebars and wheels. Even the pedals are **carbon fibre**, as well as helmets for most events.

While the number of metal components on the Olympic racing bike has decreased since the Sydney Olympic Games, metals like **chromium, aluminium** and high tensile **steel** are still used for smaller components on the bike. These metals and **carbon fibre** make the bike very strong and durable yet also extremely lightweight. It must be a lean, mean cycling machine capable of taking the rider around the track at incredible speeds and under great stresses.

Meet Anna Meares, a well known sportswoman we found training at the Adelaide Super-Drome.

Anna is sponsored by mining giant BHP Billiton and is competing in the 2012 London Olympics. We will use her racing bike as an example for this activity.

Light

In racing, weight is a most important consideration. The lighter the bike, the faster the cyclist can make it go. Carbon Fibre can make a bike that is very light.

Anna's bike weighs just 6.8kg

Compare this to an everyday bike.

Strong

Anna's bike is put under a lot of strain on a racing track as the slope can be 42 - 47 degrees. Imagine how much stress is put on the frame and the wheels when riding at that angle!

INVESTIGATION

The aim of this activity is to learn what materials and metals Anna's bike is made from and identify how each helps make her bike a lean, mean cycling machine.

WHAT YOU NEED

The two tables - Features of Anna's Bike and Characteristics of Materials

Features of Anna's Bike

PART	CHARACTERISTICS	MATERIALS
Pedals	Lighter than aluminium, hence lower rotating mass. Manufactured in aluminium or steel compression moulds. Easy to produce and less post production finishing. Axles and contact patches made of steel as it is harder wearing and can be fabricated and machined easily.	Carbon fibre and steel
Frame	For the same strength, a carbon fibre frame weighs less than a bicycle tubing of aluminum or steel. Diamond or triangular shape distributes the stresses and strains over the front wheel and the frame. The frame can be moulded so that there are few joints and welds.	Carbon fibre
Wheels and Tyres	Wheels are used for movement and control. Disc wheels reduce air drag – they are two skins. More aerodynamic than a spoked wheel. Generally lighter. Easy to manufacture in a CAD designed aluminium mould. Lighter rotating mass, but extremely rigid. Tyre is one piece with tube encased inside, glued to the rim and inflated. Inner tube weighs as little as 100g and is sometimes inflated with helium. Why? (Hint – think of a balloon!)	Carbon fibre Cotton
Nuts and bolts	Tensile strength (TS) is the maximum stress that a material can withstand while being stretched or pulled before it deforms. High tensile steel is a medium carbon, chromium and molybdenum alloy steel.	High tensile steel
Crank bracket threads/ rear wheel tips/ cranks/ wheel hub centres	Aluminium - hard points. Made of 7000 series aluminium as it is hard wearing and can be machined relatively easily.	Aluminium
Wheel bearing surfaces	Chromium plated steel surfaces that have been machined for the bearings to run smoothly. Hard wearing and low friction surface.	Chromium

Characteristics of Materials

MATERIAL	WHY IT IS USEFUL
Carbon Fibre - is a polymer which is a form of graphite. Graphite is a form of pure carbon.	Carbon fibre is an extremely strong material that is also extremely lightweight. Engineers and designers love it because it's five times as strong as steel, two times as stiff, yet weighs about two-thirds less. Carbon fibre is very thin strands of carbon - even thinner than human hair. The strands can be twisted together, like yarn. The yarns can be woven together, like cloth. To make carbon fiber take on a permanent shape, it can be laid over a mold, then coated with a stiff resin or plastic (like how you would make something out of papier-mâché by putting newspaper strips over a mold, then adding paste to force it to hold the shape).
Iron	Main metal used in steel making. Soft by itself. Easily corrodes.
Molybdenum	A silvery metal that is added to steel, to harden it. It increases the tensile strength at high temperatures and is good for parts that get hot.
Chromium	When exposed to air, the chromium forms an invisible layer that protects the metals underneath from corrosion (rusting). When alloyed with steel, it increases the strength and hardness. Many different colours can be found in chromium so it is used in paints and pigments.
Aluminium	Not very strong metal on its own. Lightweight metal which, when mixed with steel, reduces the overall weight of the alloy. Resistant to corrosion.

WHAT TO DO

1. Carbon fibre is lightweight, durable and safe. If we used carbon fibre more in the manufacturing of cars, we could make them lighter and reduce their fuel consumption. What are some of the difficulties with using carbon fibre?
2. In what ways does aluminium help make Anna's bike a lean, mean cycling machine?
3. What shape is the main frame on Anna's bike? Why do you think this shape is almost always used for bike frames? Draw a diagram of Anna's bike outlining where this basic shape is used. Look around your school or community for examples of constructions using this basic shape for strength.

DID YOU KNOW?

Anna's bike has no brakes! She just has to keep rolling on until the bike slows down enough to stop. Imagine if this was the same on a road or a mountain slope.

Anna's helmet has been aerodynamically designed for less wind resistance. It is made from carbon fibre or Fibreglass. These are both 'composite' materials which are mixtures of two or more materials. They are made from carbon, which forms when coal is heated, or glass strands. The carbon and glass strands can be put under a lot of tension, but are too floppy to use alone, so a resin or 'glue' (often nylon) is used to join the fibres together and make them strong. The result is an extremely lightweight, very strong material.

Have you heard of the 'Super Roo'? This is a specially designed monocoque carbon fibre bike that helped Kathy Watt, Bradley McGee and Stuart O'Grady win three gold medals at the 1994 Commonwealth Games. Scientists and engineers from the Australian Institute of Sport and the Royal Melbourne Institute of Technology designed the bike.

Check out the following links:

http://www.powerhousemuseum.com/hsc/bike/article.htm

http://www.powerhousemuseum.com/collection/database/?irn=163573

For further information on the various cycling events for the London 2012 Games:

http://www.london2012.com/games/sport-competition-schedules/olympic-sport-competition-schedule.php?sport=Cycling+-+Track&venue=&date=&Search.x=26&Search.y=20

Information Sheet - History of Cycling

The bicycle has undergone many changes over the past 200 years. These changes have not only been in the design, but also the materials that have been used to make them.

The first bike of sorts was made in Paris around 1790. It was wooden, and actually required the rider to 'walk' it as it had no pedals!

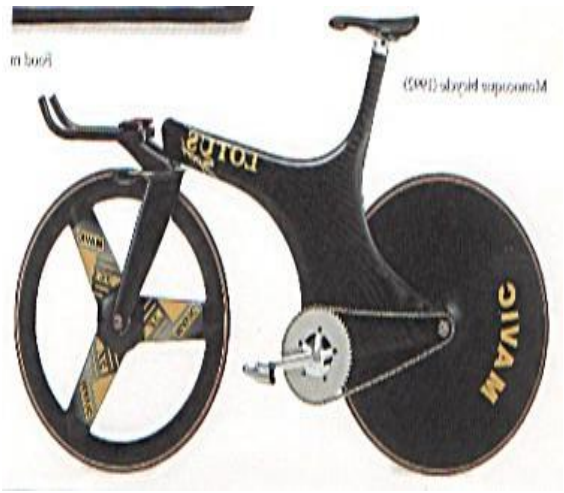
Within a short time, many kinds of bikes with lots of unusual bits and pieces were designed. Some of these were rather weird and had a very short life. However, as better technology and materials were discovered, others developed over time into what we ride today.

c1870 - The Velocipede or 'man-powered vehicle', known as the boneshaker.

Wheels were of wood but the frame was wrought iron. Brakes were a block of wood mounted on an iron bed. Pressure was placed on the back wheel by twisting the handle bars which shortened a cord. Pedals were fitted to the hub of the slightly larger front wheel and it was fitted with brass bearings so it could turn from side to side. The saddle was on a spring fitted to the back wheel with a bolt. A mounting step on one side helped the rider get on. The bike required lots of leg muscle.

c1880 - The Penny Farthing
A lot of skill was needed to get on and off this machine. A jagged mounting step was added later to assist. The brake worked by twisting the front handle bars which tightened a cord and applied a metal stop to the back wheel. The front wheel was larger so more ground was covered in one revolution - one turn of the pedal gave two turns of the wheel. The diameter of the front wheel ranged up to 150cm. The back wheel was small to reduce weight. The bike weighed around 12kg. Metal was used for its construction.

c1885 - The Rover Safety Bike
Regarded as the forerunner of the modern bicycle, it had direct steering, an adjustable saddle and a forked head. The rear chain was a new development, as was the use of ball bearings in the wheel hub caps. The beginning of the diamond frame can be seen. This was tubular steel and meant that machines could start mass-producing the bikes. The drooping cross bar and the front forks made the bike stronger than any others before. Solid rubber tyres were used but these were soon replaced by air filled pneumatic ones. Both wheels were about the same size.



1990s - Monocoque.

This is the bike that powered Chris Boardman to gold in the 1992 Olympic 4,000m pursuit. It features a single, hollow, moulded, shell frame to reduce stress on welded joints; lightweight alloy crank, pedals and chain; narrow tyres to reduce rolling resistance; forearm rest and hand grips; narrow racing saddle for freedom of movement. It does not have any gears or brakes.

Eye Witness Science Book – Technology, 1995, London

DID YOU KNOW?

In 1493 Leonardo da Vinci drew a plan of a machine that looked remarkably like a bicycle, with pedals, brakes, handlebars and a toothed gear like a chain. Why was his idea not invented until much later?

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www.cadelevans.com.au/

http://www.powerhousemuseum.com/hsc/bike/article.htm

www.cycling.org.au

www.minerals.org.au links to websites in other States and Territories

http://www.paralympic.org.au/sports/cycling

http://www.howstuffworks.com/fuel-efficiency/fuel-economy/carbon-fiber-oil-crisis1.htm

ACKNOWLEDGEMENTS

Oresome Resources would like to acknowledge Bryan Hayes, Mechanic, Australia Institute of Sport Cycling, the Minerals Council of Australia, South Australian Chamber of Mines and Energy and BHP Billiton for their assistance with this resource.