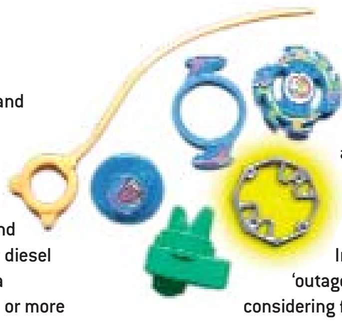
Engineering Excess
A closer look at WHEELS

We take wheels for granted and almost always think of wheels in a blinkered way. Making vehicles and products in school that feature wheels in a stereotypical ways.

This article takes a celebratory and closer look at the wider world of wheels.



Ever since the dawn of time we have been trying to move things and adding wheels and reducing friction has been a key activity. Wheels of course do far more than move us.

Flywheels are a good example of the hidden wheel... They rotate and store kinetic energy until needed and provide a smoothing and damping effect for shock loads and power pulses from a petrol or diesel engine. Their ability to store energy is most simply witnessed in a freewheeling bicycle wheel that can spin unimpeded for a minute or more once 'spun up'. Designers and engineers use this kinetic energy store in a variety of ways. Not just as flywheels in cars and motorcycles but to provide immense energy instantly in a fly press in cutting and forging metals. *Oerlikon* and other manufacturers in Europe embarked on the manufacture and operation of 'Flywheel buses' from the 1950's that used the flywheel energy to operate the buses up mountain passes and to 'recharge' down them. They needed regular stops to electrically 'spin up' the flywheels and recharging took a few minutes every 5-6 kilometres and thus lost favour on longer routes. The flywheel could weigh up to 1500kg.
Flywheels store energy just as a battery does but of course without any acids, gases or electrical cabling. A potter's wheel and a treadle lathe or early sewing machine, are also good examples of the flywheels power smoothing effects and energy storing capabilities.

1950 Gyrobus
Electricity to drive the Gyrobus was generated en-route with a fly-wheel of 1500 kg.

For this reason a number of car manufacturers developing *hybrid electric vehicles* (HEV's) are intensely interested in using the flywheel as an energy store. To store useful amounts of energy, essentially we can make extremely heavy wheels that store energy and rotate relatively slowly or we can construct much lighter wheels to rotate at speeds up to 200,000rpm! At these speeds really light composite materials are needed. Metal flywheels would have simply disintegrated at much lower speeds. NASA are contemplating using such composite flywheels to store solar energy on space vehicles as they have a much longer life than batteries and make more power and 'deep cycle', that is discharge fully and recharge more readily. At these speeds rotors need to be run in a vacuum. Also weight for weight these composite rotors could store more energy than conventional batteries.

In this dismantled child's toy we can clearly see the flywheel made of die-cast white metal that places almost all the mass of the toy at the outer edge allowing it to 'flywheel' and spin for an extended period.

In California, scene of recent power cuts and grid supply 'outages', hospitals and key installations are seriously considering flywheels as a backup source of electricity that can be switched instantly rather like a super capacitor. London Underground have also conducted trials using the effects of regenerative braking of tube trains to 'recharge' a flywheel and think a 20% saving in energy is possible and the flywheel provides the additional boost of energy via a generator as the train accelerates away again.

If we take a bicycle wheel and grasp the hub between our hands and try and deflect it from its direction of rotation the mass resists that deflection and demonstrates its ability as a gyroscope rather than simply a flywheel.

The first artificial horizon in aircraft using a gyroscope was as early as 1916! This remarkable Gyro Car used a single spinning rotor at 6000rpm to keep the car upright and it worked, despite needing several minutes to spin up the gyro before starting a journey. The rotor could also provide an instant source of power for amazing acceleration. Why didn't this idea take off?

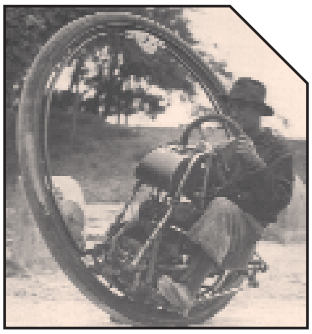
Gyroscopic Car

Honda Hybrid

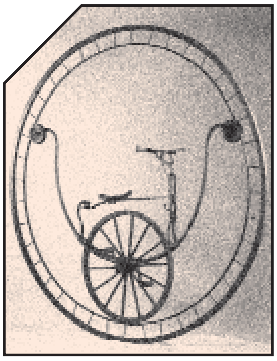
Jean Bernard Leon Foucault invented the *Gyroscope* in 1852 and we have been using them ever since. From basic children's spinning tops to ships stabilisers, gyrocompasses and autopilots and artificial horizons all use the unusual 'coriolis' effect created by the gyro.
The most recent gyroscopic devices are solid state, like that used in the *Segway Human Transporter* (far right). Inside, a silicon gyroscope consists of a tiny silicon plate mounted on a support frame.
The silicon particles are moved by an electrostatic current applied across the plate. The gyroscope system measures the change in vibration of the particles as the 'HT' is tipped and tilted and passes this information on to the computer that in turn controls the two drive motors.

Concept Honda IMAS
This hybrid sports car has two wheels powered by conventional fuel and two wheels powered by electricity.

Mono Cycle
The Rocket Roadster with owner/designer Kerry Mclean



Motor Wheel *1931*
Swiss engineer Mr. Gerdes astride/inside his one-wheel motorcycle



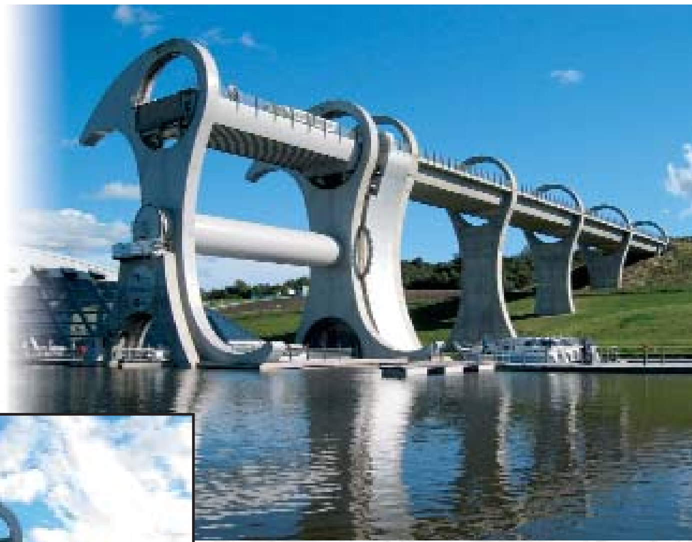
Mono Wheel *1869*
This elegant cycle was built by Rousseau of Marseilles, though there are certainly two wheels involved.

During the early part of the 20th Century there was an enduring interest in *Mono Cycles* and as their name implies they featured a single wheel in which the rider/driver sat or pedalled. These perhaps were an extreme variation on using the wheel for transport. Balance and steering have remained problematic throughout their development. Shown above is a typical 1930's machine and a more recent outrageous version the *'Rocket Roadster'* with its owner, designer *Kerry Mclean*.

The really exciting wheels are even bigger. *The London Eye* and the *Falkirk Wheel* are impressive examples of larger than life wheels.

The Falkirk wheel as its name implies resides near Falkirk in central Scotland at the junction between the Forth and Clyde and Edinburgh and Glasgow Union canals. The two levels of canals are 115 ft apart (almost 8 double decker buses) and for many years alternative lifts had been proposed. The original flight of eleven locks had long since gone. The final design of rotating gondolas and structure weighs some 13,000 tonnes. Two claws or beaks on arms rotate anti-clockwise about a central axle.

Ascent and descent takes about 15 minutes and it can carry up to 8 boats at a time. Drive to the central axle is by ten hydraulic motors through planetary gears. A further train of (synchronous) gears is used to maintain the upright position of each gondola rather than just relying on gravity. Monitoring water levels in the upper and lower basins and in the gondolas is done via computer. Because the wheel is in almost perfect balance with around 300 tonnes of water in each gondola or caisson only a small amount of energy is required to rotate it.



Falkirk Wheel

The London Eye also provides a different perspective on construction and in this view the spokes of the wheel are reminiscent of the tension spokes attached to a bicycle hub. The outer rim that supports the gondolas is a triumph of assembly of tubes and triangulation.

With a little imagination and preparation we can take advantage of the wide range of inspirational material available and get our students thinking and creating new and novel applications for the humble wheel.

London Eye *'Spokes'*

SEGWAY

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can self-balance because of a technology called dynamic stabilization.
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