

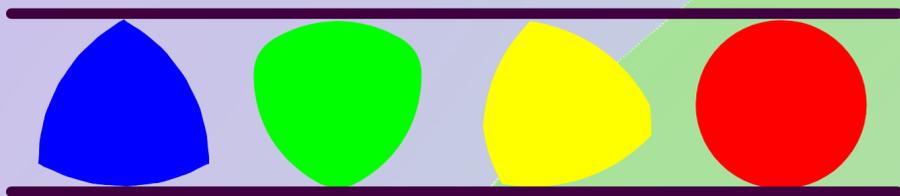
# WONKY WHEELS

## The Reuleaux Triangle and other Curves of Constant Width

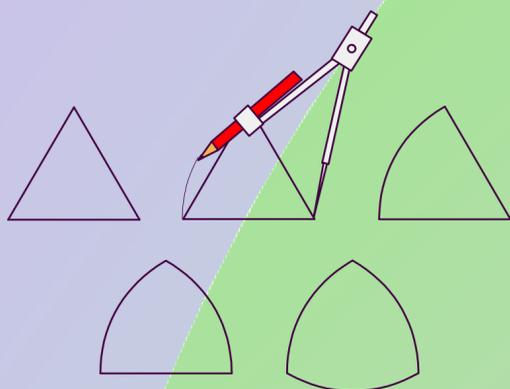
A circle's diameter is the same, no matter which direction you measure it. It is a curve of constant width—but not the only one. Lots of shapes have a constant width and you will find them in strange places—even in a drill that drills a square hole!

### Curves of Constant Width

All of these shapes can roll between the two solid lines - touching both lines as they roll. They are all the same width no matter which way they are orientated. Curves of constant width are not just a mathematical curiosity, they are used everyday.



Even though curves of constant width roll easily, most make poor wheels. Just imagine riding this bicycle!



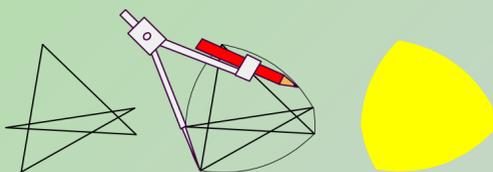
The simplest curve of constant width is the Reuleaux triangle. You draw a Reuleaux triangle by starting with an equilateral triangle and drawing arcs on each side. The Reuleaux triangle is used in many real applications as we will see later.

You can "round-off" a Reuleaux triangle by extending the sides of the triangle and drawing six arcs as shown. This process produces a shape that rolls a little easier but still has constant width.



You can perform the same processes on any odd sided regular polygon and produce Reuleaux pentagles, heptangles and so on. You should notice that the more sides you add, the more circular the shapes look.

You can also draw odd shaped curves of constant width. Start with a star where every side is the same length and then draw arcs as indicated.



### Did You Know?

A Reuleaux triangle's perimeter is its width multiplied by  $\pi$  – just like a circle. Is this true for all curves of constant width?

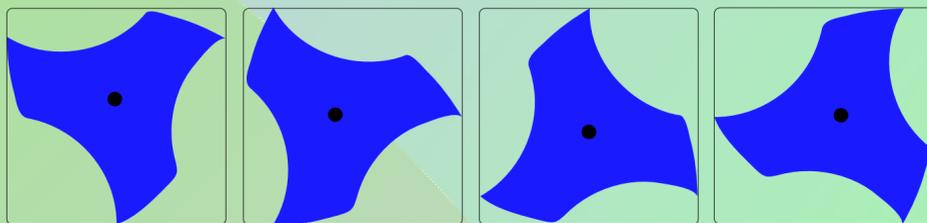
### Wonky Money

The United Kingdom 20 pence and 50 pence pieces are Reuleaux heptangles. The designers of these coins had a very good reason for not making the sides straight. Can you work out what it is? Think about it the next time you put coins into a vending machine.



### Drilling Square Holes

A Reuleaux triangle can be rotated inside a shape that is almost a square. The only problem is you cannot just spin the triangle. That would produce a circular hole. To drill a square hole you have to move the centre of the triangle at the same time.



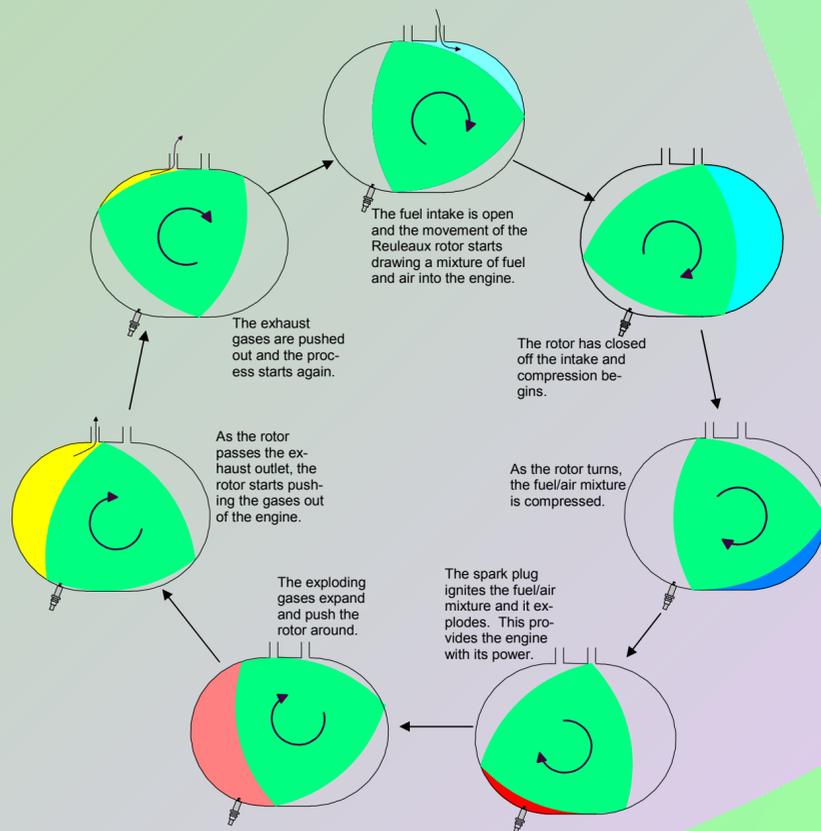
Harry Watts used this idea to design a drill bit that can drill a square hole. The cutter is a Reuleaux triangle that has had sections removed and it is placed in a special chuck that moves the centre of the triangle as it spins.

What is happening to the centre of the drill bit as it spins?

### The Wankel Rotary Engine

Once of the most famous uses of the Reuleaux triangle is the rotary engine designed by Felix Wankel. The Wankel rotary engine uses a Reuleaux triangle rotor which rotates inside an oval shaped casing. In the diagram below, you can follow one cycle of intake, compression, ignition, expansion and exhaust as one side of the rotor moves around the casing.

Just like the Square Hole Drill, the rotor is not just spinning, the centre moves in a circular motion.



Franz Reuleaux (1829-1905) was a distinguished German mechanical engineer. He had a particular interest in kinematics—the science of turning one mechanical motion into another.



Felix Wankel (1902-1988) combined imaginative invention with a scientific approach to engineering. His company, based in Germany, became world leaders in rotary engines.

Harry Watts developed the square hole drill in 1914. His company, Watts Brothers Tool Works, still sells square hole drills as well as drills to drill pentagonal, hexagonal and octagonal holes.

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