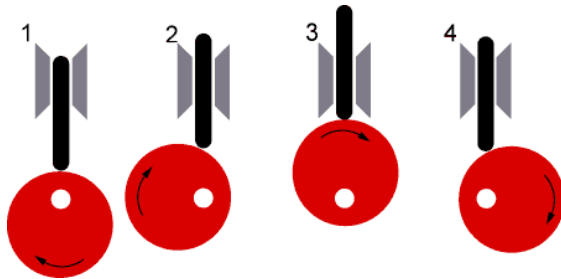


## Cams

Cams spin around to push something else (usually a rod or a piston) up and down in a straight line. The rod or piston is also known as a follower.

Most cams are circular. Some cams are shaped like an egg or even a starfish or a snail! If you change the shape of the cam, you can set the pattern for how the follower moves up and down, as well as how far it moves.



As the red cam rotates clockwise, it pushes the black follower up and down within the grey guides.

## Cams in Imagination Factory

There are three cam exhibits in *Questacon Imagination Factory—Invent and Play*. They are:

- Toying with Cams;
- Crank the engine; and
- Crack the Cam Lock

## How do cams make life easier?

Cams turn rotary motion into up-and-down motions.

- Cams allow machines to apply pressure at particular moments in the cam's cycle. They are used in sewing machines to push the needle and thread through material in regular patterns.

- When many cams are threaded together on a camshaft, cams allow you to control the up and down movements of followers in particular sequences. Camshafts are used in car engines to open and close valves in sequence and control the flow of air, fuel and exhaust running through the engine.

## Quirky Fact

Eccentric cams can generate beautiful patterns! The Spirograph is a popular child's toy that draws intricate spiral patterns as toy gears rotate inside a circular toothed frame. The gears act as unusual eccentric cams.

In each toy gear, a pencil tip takes the place of the axle, and the outer frame of the toy acts as a follower.

Because the frame is rigid, it does not move – instead it forces the toy gear's free axle to move up and down as the gear rotates. The pencil point at the axle draws intricate spirals. The closer the axle is to the edge, the more eccentric the pattern becomes.

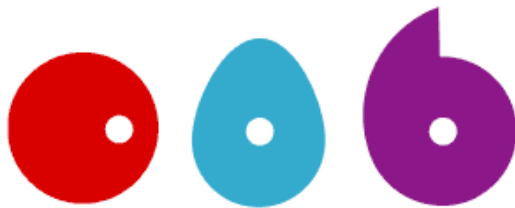
## Everyday uses of cams

Cams come in lots of amazing shapes!

- Circular cams, also known as eccentric cams, are circle-shaped and fitted off-centre onto the driving shaft. These cams move very smoothly and are used to generate a wave-like motion in the follower. They are often used in mechanical toys to produce a smooth, recurring motion.
- Pear-shaped cams are actually egg shaped. The follower is level for most of the cam's rotation, then is suddenly pushed up at regular intervals. These are used in car

engines to control the flow of air/fuel and exhaust in the engine.

- Heart-shaped cams allow the follower to move at a constant velocity and therefore provide a very steady motion. They are used in sewing machines to wind thread onto the bobbin.
- Drop-cams are shaped like a snail shell. These cams lift the follower gradually, then drop it suddenly.
- The crank and slider is a special type of cam that you can find on the wheels of steam engines. It consists of a piston (the slider) that is attached to a circular cam (the crank) by a rod. The rod is offset from the cam's axle. As the piston moves back and forth, it pushes and pulls on the rod, which turns the cam around. In a steam engine, the wheel is the cam!



From left to right: eccentric cam, pear-shaped cam and drop cam.

## Extras for experts – Working with Cams

Car engines contain crankshafts and camshafts that work together to choreograph the explosions of fuel and release of exhaust that allow the engine to run.

Most cars run on a four-stroke engine. The four stages to a combustion cycle are the intake stroke, the compression stroke, the combustion stroke and the exhaust stroke.

1. On the intake stroke, a piston is pushed down the cylinder, allowing

a small amount of fuel and air into the cylinder space above it. The piston is connected to a crankshaft that rotates through half a turn.

2. During the compression stroke, the fuel and air are compressed by the piston as it moves back up the cylinder. This causes the crankshaft to finish rotating through a full turn.
3. The combustion stroke is the most interesting stroke because this is where the explosion happens! A spark plug ignites the fuel and air mixture, causing it to explode. This explosion drives the piston back down the cylinder and causes the crankshaft to rotate a half-turn again.
4. During the exhaust stroke, a valve in the cylinder opens, allowing the exhaust left over from the explosion to leave. The crankshaft rotates another half-turn to end up at the top, where the process begins again.

The spinning of the crankshaft is connected to the car tyres through the car's transmission system. The power of explosions drives the car!

So where does the camshaft come in? It is directly coupled to a crankshaft and is used to control the fuel coming into the engine and the exhaust going out.

As the crankshaft spins, it causes the camshaft to spin as well. The camshaft's rotation then opens and closes the valves that allow air and fuel into the cylinder, as well as opening and closing the valves that allow exhaust to leave the cylinder.

## Examples for experts – Sew far sew good

After the car engine, the sewing machine is one of the most complex mechanical devices. It contains several cranks to drive

the needle and material through the machine.

1. The machine is started by pushing on a foot pedal. This activates a motor which drives a wheel and belt system (see pulley notes).
2. The drive wheel turns a train of crankshafts which move in sync. One moves the needle up and down. The second is a series of cams and cranks that move the feed-dog (the part that pushes the fabric along) up and down. The feed-dog holds the fabric in place during the stitch process

One basic sewing machine stitch is called a lock stitch. The steps which control the mechanics of the needle and feed-dog can be seen in the diagram below.

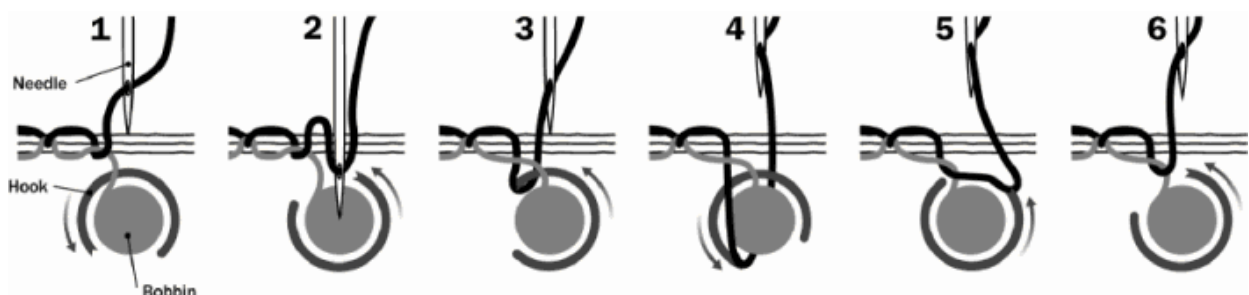
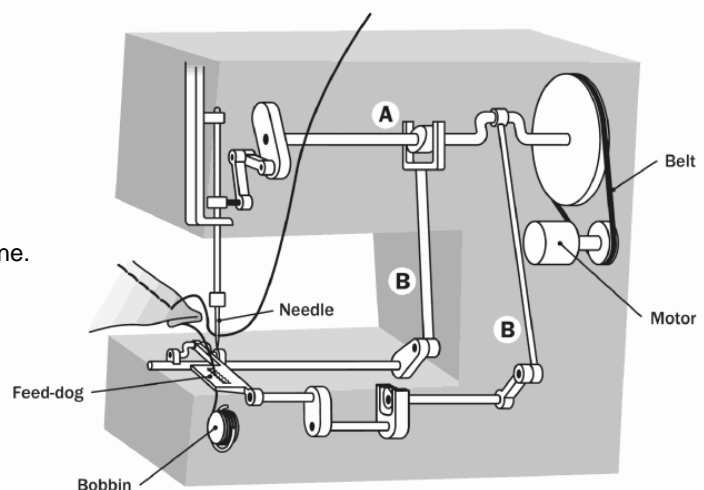
To make the lock stitch, the machine has to loop two different threads together. One thread is looped through the needle and the other is wound around a bobbin underneath the fabric. The bobbin is encased in a rotary shuttle that has a hook. The steps are:

1. The needle pierces through the fabric and moves up leaving a loop of thread under the fabric (see images 1 and 2 in the sequence of images).
2. The rotary shuttle spins and the shuttle's hook catches the thread loop (image 3), pulling it around the bobbin (image 4). The bobbin thread is pushed through the hooked thread in the process.
3. When the shuttle completes a full circle (image 5), the hooked thread slips off, forming a stitch (image 6).

Modern machines are computer controlled and use stepper motors or sequential cams to achieve very complex patterns.

Right: Crankshafts and pulleys in a sewing machine.

Below: Steps for making a lock stitch.





## Background Support Notes



### The Pulse Fishing Reel—An unusual Australian Invention

If you want to invite a fish to dinner, you have to entice it onto your hook. Anglers do this by using fishing lures that fool fish into thinking they're seeing a tasty meal floating in the water. Lures often look like a small fish or a prawn.

The problem is that larger fish aren't interested in lures that just float in place. The lure needs to dart around like the fish's real prey to look delicious!

To make the lure dart forward, anglers 'jig' the line, rapidly flicking their fishing rods up and down while winding in their line. While this helps to catch more fish, a full day of fishing like this can get quite tiring.

Perth-based inventor Andrew Maeder realised that he could make things simpler if he had a spool that would automatically jig the lure for him. Thus the Pulse Fishing Reel was invented.

#### Getting im-pulse-ive

When you wind in the line on an ordinary fishing reel, the line is usually pulled in smoothly over a guide on a wire frame called a bail, then wound around a spool that is set centrally to the bail.

The Pulse Fishing Reel looks like a normal fishing reel except that the spool can be set to rotate off-centre.

The off-centre spool acts as an eccentric cam while the section of line between the spool and the wire bail acts as the follower.

This means that the line's length becomes shorter when the spool rotates near the bail, then grows longer as the spool's eccentricity takes it further from the bail.

The shortening and lengthening of the line causes the lure to dart towards the angler as he or she winds in the line. No jigging is required!

#### Getting un-jiggy with it

Once you catch a fish, you don't want to the line to jig as you pull it in as this could make you lose the fish.

The pulse fishing reel's spool snaps back to a central position once the fish pulls against the line, allowing the line to be wound back onto the spool smoothly.

#### Find out more

##### About Cams:

- *The New Way Things Work*. David Macaulay. 1998. 48-53, 156-7.
- Howstuffworks: How do engines work? - <http://www.howstuffworks.com/engine.htm>
- Animated cam shapes - <http://www.technologystudent.com/cams/cam2.htm>

##### About the Pulse Fishing Reel:

- New Inventors website - <http://www.abc.net.au/tv/newinventors/txt/s1446891.htm>