Super Precision Gyroscope

Manual Version 9.0
April 2018

What's included

1 x Gyroscope
1 x Electric motor and battery pack
2 x Screws to attach motor to the gyroscope
1 x String to balance gyroscope on
1 x Alan/hex key for above screws
2 x Extensions
2 x Ball ends
1 x Slot end
1 x Screw for the battery box

4 x AA batteries are required for the battery pack

Note:
A number of other accessory kits are made for the super gyroscope. These include the ***gimbals add-on kit, rate kit*** *and* ***replacement part kit****. These are supplied in bags. If purchased at the time of the gyroscope. They are included in the gyroscope box.*

Handle like Eggs

"Handle like eggs" was often written on the side of British military aircraft gyroscopes. It may seem like an amusing phrase but it is a perfect way to convey how to treat the gyroscope. Any significant drop will damage the gyroscope. It is highly recommended when you first get the gyroscope to conduct experiments on a table with a soft cover such as a thick towel. We also strongly suggest that you never hold the gyroscope more than few inches in the air to begin with. To a novice gyroscopes move in unexpected ways!

OTHER WARNINGS

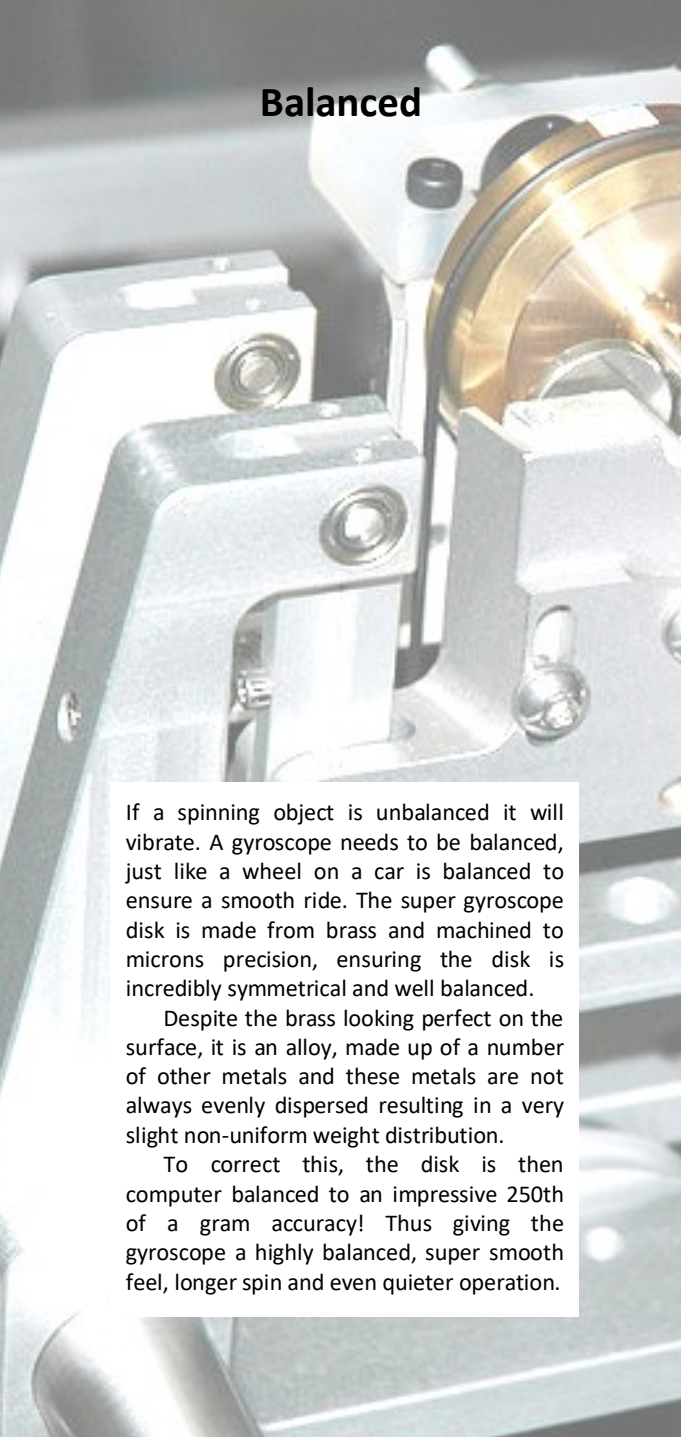
- **DON'T** touch the disk when it is spinning. It may cause friction burns.
- **DON'T** drop the gyroscope. It is a precision instrument.
- **DON'T** ever oil the gyroscope. You will damage the bearings.
- **KEEP** clothing such as ties away from the spinning disk.
- **KEEP** long hair away from the gyroscope while the gyroscope is spinning
- **KEEP** gyroscope away from young children.
- **ENSURE** older children are supervised when running the gyroscope

About the gyroscope

This gyroscope has been designed and built to the highest precision from the very start, made from solid brass with a light-weight aluminium frame. Carefully chosen stainless-steel miniature ball bearings allow it to run smoothly and almost silently. The gyroscope operates at up to 12,000 revolutions per minute using the provided electric motor and battery pack.

The motor can be fastened to the gyroscope with two screws providing hours of continuous use or it can be used briefly to start it, allowing you to perform experiments for around 7 minutes. The gyroscope comes with a number of attachments allowing numerous configurations to perform scientific, educational or simply mesmerising experiments.

Balanced



If a spinning object is unbalanced it will vibrate. A gyroscope needs to be balanced, just like a wheel on a car is balanced to ensure a smooth ride. The super gyroscope disk is made from brass and machined to microns precision, ensuring the disk is incredibly symmetrical and well balanced.

Despite the brass looking perfect on the surface, it is an alloy, made up of a number of other metals and these metals are not always evenly dispersed resulting in a very slight non-uniform weight distribution.

To correct this, the disk is then computer balanced to an impressive 250th of a gram accuracy! Thus giving the gyroscope a highly balanced, super smooth feel, longer spin and even quieter operation.

Balancing Holes

There will be a number of holes on the periphery of the brass disk. The gyroscope is tested for imbalances. Once the imbalances have been found the holes are drilled to remove weight on precise parts of the gyroscope to balance the weight of the gyroscope. This process is repeated until the gyroscope is balanced to 250th of a gram. The process is very similar to balancing of a car tyre, just extremely more accurate.

Spin times

If you spin it to its full speed and place it on a desktop without doing anything it should run for about 25 minutes (time to complete stop). However various experiences will take energy out of the gyroscope. So while doing some experiments the spin times will be reduced. In some cases the spin times may reduce to a couple of minutes.

Specification

RPM	12,000rpm+
Weight	
Total Weight :	345g / 12.16oz
Gyroscope weight without	145.3g / 5.12oz
Brass disk (without shaft) :	111.2g / 3.92oz
Alu casing, bearings, shaft	34.1g / 1.2oz
Shaft (includes bearing	4.7g / 0.16oz
Bearings :	0.6g / 0.02oz
Aluminium casing :	26.1g / 0.92oz
Screws (hold case	2.7g / 010oz
Electrical Characteristics	
Motor Amps (start-up):	2.5 amps / 14.5w
Motor Amps (at full rpm):	0.5amps / 3w
Motor Voltage:	5.8~ volts
Nominal Motor Voltage:	6 volts
Batteries :	4 x 'AA' (LR6)
Gyroscope Dimensions	
Outer casing diameter :	62.5mm / 2.46in
Brass disk diameter :	53mm / 2.08in
Brass disk thickness :	12mm / 0.47in
Brass disk cut-out depth :	5.25mm / 0.21in
Brass disk cut-out	40.9mm / 1.61in
Shaft Diameter (largest	4mm / 0.15 in
Motor length :	58.2mm~
Motor diameter:	28.1mm~
Physics	
Moment of Interia:	0.000055 kg m^2

Starting the gyroscope

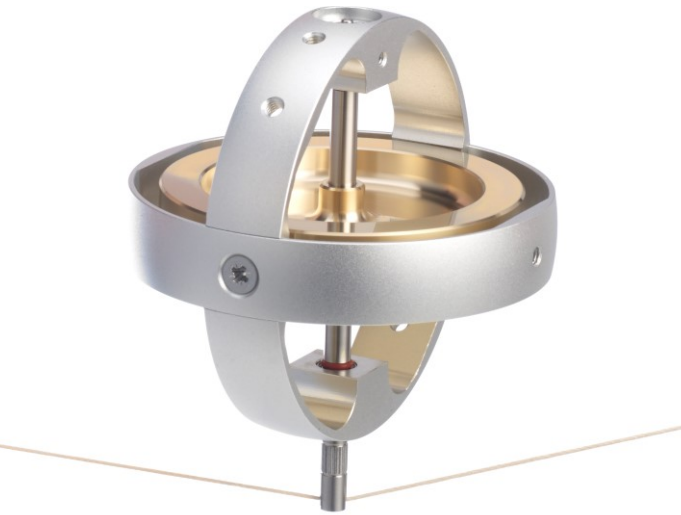
1. Hold the gyroscope's frame in one hand.
2. While the motor is OFF push the motor onto the axle of the gyroscope.
3. Holding the motor and gyroscope firmly together turn the motor on (switch is on battery box)
4. Wait until the gyroscope gets to the required speed and pull motor away from the gyroscope
5. Turn OFF the motor (You are now free to conduct experiments with the gyroscope)

Should you want the motor permanently attached, then push on the motor and screw in the two screws using the supplied Alan key. You can then use the motor itself as a handle.

Gyroscopic Forces: Suspending by string

Screw one of the ball ends into the opposite side of the gyroscope that you connect the electric motor. Start the gyroscope spinning. Hold both ends of the string and put the 'ball' end into the loop of string. Raise the gyroscope. The gyroscope will roughly maintain its angle to the horizon. Prepare to catch the gyroscope when it slows down. You will notice that as the gyroscope disk slows down its rotations around the string (precessing) will speed up.

Gyroscopic Forces: Balancing on string



Screw the ‘slot end’ into the opposite side of the gyroscope that you connect the electric motor. Place the gyroscope onto a taut string or wire (note the slot in the bottom). The gyroscope with remain on the wire until it slows down. Be ready to catch it.

Gyroscopic Forces: Simple Precession

Screw one of the ball ends into the opposite side of the gyroscope that you connect the electric motor. Spin the gyroscope up using the electric motor. Now place the ball end of the gyroscope onto a flat surface and let go. Watch as it remains upright to begin with but then starts to slowly twist around on the ball end. This is called precession. As the gyroscope slows down the precessing will speed up and the gyroscope will start to tilt over.

Adding an extension

Repeat the demonstration above but this time use one of the extensions between the ball end and the gyroscope. You will notice that the gyroscope precesses much faster. Be prepared to catch it because it will topple quicker than you expect. You can also try 2 extensions! Typically it will topple over in about 1 second. So be ready to catch it and make sure there is a soft surface for it to land on. Tip: a rubber or silicone mat will slow down the precision due to friction on the pivot point. This can be useful!

Balancing on your finger

You can try balancing it on your finger. It is probably a good idea to do the other demonstrations first so you know how the gyroscope behaves. Don't let it tilt over too much and make sure you are ready to grab it before it falls off your finger. It may also be a good idea to do this demonstration while your hand is over a soft surface such as a cushion just in case it does fall. **Remember, don't drop your gyroscope as this will likely damage it.**

Other Demonstrations

There are 7 places on the frame of gyroscope that the attachments can be screwed into. This allows you to try out the attachments in different places and explore the results.

Falling quickly

Depending on which accessories and what you are doing with the gyroscope, the gyroscope can fall over in a fraction of second or it can remain upright for minutes. Always be ready to catch it!

Noise

Once the gyroscope is at full speed and disconnected from the motor, holding it vertically (shaft pointing up) it will be relatively quiet. However no mechanically moving components are completely silent. If you tilt the gyroscope from a vertical to horizontal position you are likely to hear a change in tone, noise or volume. You should find some orientations quieter than others; this is normal. The gyroscope is optimised for long run times. Slightly extra pressure on the bearings would reduce noise but at the sacrifice of a dramatic reduction in spin times.

Shaft movement

The super gyroscope has some slight vertical movement on the shaft (you can push it up/down by about 1mm). This is normal. There are red buffers at each end of the shaft just before the bearings which reduce impacts on the bearings if the gyroscope is dropped. It also helps reduce noise from the gyroscope in some situations.

If it is really important to have as little vertical movement as possible and you don't mind shorter spin times, then adjustments can be made with the bearing replacement kit.
https://www.gyroscope.com/d.asp?product=REPLACEKIT

Maintenance and repair

With careful and normal use the gyroscope should never need maintenance or repair. **NEVER oil** the bearings as they have special lubricant that will last the life of the gyroscope. Adding oil and mixing with different oils will cause lubricant to become sticky, slowing the gyroscope down and damaging the bearings.

If you happen to drop the gyroscope, damage to the gyroscope is extremely likely. The bearings take the brunt of the force. A fall as little as 4 inches (10cm) can make the bearings noisier. Larger falls degrade the spin times. If the bearings are damaged you can buy our bearing replacement kit to replace the bearings. Please be aware that an excessive drop (off a table or from waist height) almost always damages the disk and shaft irreparably. In extreme cases there maybe a visible wobble in the disk.

Cleaning

The gyroscope is made chiefly from aluminium, stainless steel and brass. The aluminium and stainless steel will remain bright and shiny. The finish of the brass can degrade in poor conditions. In order to keep the brass in good condition, avoid damp and humid conditions (keep above dew point). Cover or bag after use. Avoid touching the brass with your fingers; Skin can be quite acidic and overtime the fingerprints will show up on the brass. To clean the brass we recommend using a well-known and respected brass or copper cleaning product such brasso.

Gimbals add-on kit (optional)

This kit does not come with the gyroscope. It is sold as an accessory to the Super Precision Gyroscope. The kit is a modular set of twenty four components that complement and expand the number of experiments that can be performed. They are compatible with components that are supplied with the gyroscope and can be used together. One of the main features is to provide 2 axis gimbals for the gyroscope but many other experiments can be performed. The gimbals make precession and nutational forces easy to demonstrate.

What is included with the gimbals kit:

1 x Centre hub
3 x Legs (can use as extension rods)
3 x Feet (connects to ends of legs)
3 x Hex screws (secures feet/legs)
3 x Rubber O rings (fit on feet)
2 x Gimbal vertical arms
2 x Thumb Screws
1 x Counter weight
1 x Plastic washer for top of hub
1 x Pin (fits into hub and horizontal arm)
1 x Hex screw (secures horizontal arm)
1 x Centre beam (Hex screw attached)
1 x Grub screw for counter weight
1 x Alan/hex key

CAUTION!
The gyroscope gimbals kit comes with 2 thumb screws. Be careful not to screw them into the gyroscope directly. In some of the 7 positions on the gyroscope the screw can touch the brass disk. This WILL DAMAGE the gyroscope.

Putting the gimbals kit together for the first time

There is one thing you need to do before you use the gimbals. This only needs to be done once. You will need the centre beam, the two vertical arms and thumb screws. Put them together as show in the picture below.

Tighten the thumb screws up hard just using your hand. Wiggle the vertical arms quite hard towards one another. If there is a small amount of movement tighten the thumbscrews and repeat. Keep doing this until there is no more movement. This ensures the gimbals kit is a good fit when the gyroscope is clamped in place as in configuration 2.

The gimbals kit enables numerous configurations and experiments to be performed using the gyroscope. We have listed just some of the configurations below.

Configuration 1

This is the simplest configuration using the gimbals kit. This experiment can be easily done without the gimbals kit but using the gimbals kit keeps the ball end of the gyroscope secure in one place. Note: The part the ball sits on can be reversed. In this experiment the concave end should be facing upwards.

Configuration 2

This configuration uses most gimbal parts and is ideal to learn some of the fundamentals of gyroscopes. Move the gyroscope around while it is not spinning and then spin it up using the electric motor. Move the gyroscope the same as before and see what happens. You can also try holding the entire gyroscope and gimbals while it is spinning on the palm of your hand. Point the gyroscopes axle north. Now walk around the room in a circle. Did you notice how the gyroscope continues to point in the same direction?

Configuration 3

Using the same configuration as configuration 2 but using one or two of the extension rods that come with the gyroscope, screw them into one of the threaded holes of the gyroscope. Spin the gyroscope up using the electric motor and lift the extension rods up like shown in the picture. Let go and watch what happens. The gyroscope will slowly precess around.

Configuration 4

This is the same as configuration 3 but utilises the counter weight. Notice the difference with and without the counter weight. Try the counter weight on the end of an extension rod (as shown) and directly connected to the gyroscope.

Configuration 5

This configuration uses the centre beam. One or two extension rods are screwed into the gyroscope (one is used in picture). The extension rod is then slid into the centre beam. You can then tighten up the screw in the centre beam with the provided Alan/hex key. Spin up the gyroscope and lift the gyroscope up and let go. You will see that the gyroscope spins around the gimbals. You may want to try adjusting the gyroscopes distance from the centre beam and watching what happens when the gyroscope slows down. Please note that nutation is also visible in this experiment.

Configuration 6

This configuration is very similar to the previous configuration but with the counter weight added. Again try experimenting with the positioning and see what happens.

Configuration 7

You can balance the gyroscope on a piece of string without the gimbals kit, however it is safer to use the gimbals as you will have your hands free to catch it when it does finally fall off. The string can be threaded through the uprights and then wrapped around the thumb screws. Undo the thumbscrews and tighten again trapping the string to make it very secure. Note: The slot end attachment needs to be used.

Configuration 8

If you have two gyroscopes you can link them together. Firstly remove the grub screw and counter weight. Take one of the extension rods and put the grub screw into the end. Tighten with the Alan/hex key. You now have a thread at each end of the extension. Screw both ends into a gyroscope. Start the gyroscopes and see the effect.

Rate kit

A rate gyroscope is a gyroscope that shows the rate of precession (the rate of directional change). For example most aircraft have a rate gyroscope that shows how many degrees the aircraft is turning left/right per second. This kit turns the super gyroscope and gimbals kit into a rate gyroscope making it an ideal demonstration for pilot training. Spin the gyroscope up and push the gyroscope around with your finger. The gyroscope will tilt the gauge to show the rate of change. The quicker you push the gyroscope the greater the reading on the gauge. The rate kit is just like on an aircraft but much simpler and all the workings visible.

Rate kits requires:

- Super gyroscope
- Gimbals add-on

The Rate kit add-on is purchased separately to the super gyroscope.

Replacement part kit

Although the super precession gyroscope comes with high quality stainless steel bearings that are robust, some customers have had accidents and damaged the gyroscope. For example the gyroscope may get dropped. This can often happen in educational environments in schools, colleges or universities. Although the bearings still operate, the cage of the bearing is damaged resulting in shorter spin times and bearings that become very noisy. For these rare occasions we have developed a bearing replacement kit. The kit consists of 2 new stainless steel bearings, 2 rubber O rings and a custom made tool to remove the bearings.

NOTE: There have been a few variations of super gyroscope. Watch the video to see how to replace the bearings. However **please be aware** that later versions of the gyroscope have a grub screw (side of where you put the special tool into the gyroscope). **If there is a grub screw, remove it using the supplied Alan key <u>before</u>** replacing the bearings. Then put back in once replaced. If in doubt e-mail us.

Warning: Please do not attempt to remove the bearings without the custom made tool.

Replacement part kit purchased separately to the super gyroscope.

Few people understand the importance gyroscopes play in the modern world. Gyroscopes are used in a diverse range of products such as cameras, phones, toys, cars, planes and even some computer equipment. Even if it does not contain a gyroscope, gyroscopic forces can still play a crucial role.
The super gyroscope comes with a number of attachments allowing numerous configurations to perform scientific, educational or simply mesmerising experiments. The optional gimbals add-on kit (purchased separately) dramatically expands the range of experiments turning it into an ideal educational tool.

- Includes electric motor starter
- 12,000 RPM
- High speed miniature ball bearings
- Balanced to 250th of a gram accuracy
- Spin time up to 25 minutes
- Very high precision manufacture
- Interchangeable attachments
- Many options for experiments
- Electric motor can be detached
- Heavy solid brass disk
- Stainless steel shaft
- Ideal for colleges and universities
- Efficient motor allows hours of use
- Can be used as executive 'toy'
- Designed and built in Britain

This product is not a toy.
It is a precise scientific instrument.

Brightfusion Ltd, Gloucester, England

Not suitable for children under 3 years old.Small parts may be a choking hazard.