# Dare we teach tops?



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# Dare we teach tops?

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**Abstract**
*Tops* are mentioned in classical literature and references are even found in the ancient world. For many children a top is one of the first mechanical toys that they play with by themselves, yet a full appreciation of their motion is rare. My hope is that this article will stimulate the reader's interest in tops, will help with the first stages of understanding, and will provide inspiration for looking into the subject further. As a result of this, teachers will be happy and have the confidence to discuss these wonderful toys with their pupils.

The article discusses tops and spinning objects of various types, and relates them to some of the physical principles that they demonstrate.

It is strange that perhaps the toy that can be found in most countries around the world is often ignored in schools. Yet this toy is familiar to children from the earliest of years, and its principles are applied in household gadgets and a wide range of sports, and games (figure 1). One of the recent crazes in English schools is the diablo, and whilst even young children perform amazing tricks, both they and their teachers may be unable to discuss the physics behind what they are doing. The purpose of this article is to raise awareness of the many aspects of physics that are opened up through *tops and spinning objects*, and hopefully encourage the reader to delve deeper. It is an area that can offer challenges both physical and intellectual, and also provide a great deal of fun.

In addition to the motion of a top, spin is fundamental to bicycles, electric drills, roundabouts, frisbees, coffee grinders, gyroscopes and navigation, not to mention the vast majority of sports—football, tennis, snooker, discus, high jump, ice skating, gymnastics and diving (and most children will be familiar with most of these before they reach secondary education). Children visit theme parks which literally have rotational physics at every turn! Understanding the stability of our own planet's motion and solar system requires an appreciation of rotational motion. Tops appear

**Figure 1.** Baby with top, an early experience of physics for a child aged 9 months, May 2009.

in almost every culture of the world, throughout the ages from the ancient civilizations to modern day. They are referred to in literature, including Homer's *Iliad* [1] (written around 800 BC) and several of Shakespeare's plays [2]. So let us grasp this nettle and look at ways in which it can be understood from a child's early days. We should

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**Figure 2.** Basic spinning top, hand spun using a narrow stem. The low centre of mass makes it easier to spin.


**Figure 3.** A selection of child's spinning tops from a local supermarket toy department.

all have a working knowledge of some of the principles which govern spinning motion when we enter the classroom to face our pupils, enthusiastic about their latest 'toy', which may just be one that rotates!

This is not a university treatise on the mathematical aspects of angular momentum and moment of inertia—those details can be found elsewhere [3]—but is an introduction to this fascinating subject to whet the appetites. I will therefore at times describe what we physicists may prefer to call angular momentum as 'spin' which may make the reading easier for those not so familiar with advanced physics. Understanding physics can be like peeling an onion, each layer revealing another level of understanding. We can have a simple but true understanding—the first few layers of the onion—and as we ask further questions, and peel more layers, the understanding deepens. This is certainly the case with 'spin'.

Firstly, consider a humble spinning top (figure 2). There is no clearer demonstration of continuous friction free motion in the absence of retarding forces than a top which has been set spinning on a smooth, hard surface. The 'point' of contact on a hard smooth surface ensures minimal solid frictional losses, and air resistance is minimal, as the top is not moving bodily through the air providing additional drag through turbulence, so it continues to spin for a while. Tops are readily available in toy shops, gift shops and supermarkets, and the simplest are easily spun with a twist of the finger (figure 3).

These small tops often utilize the longevity of spin to demonstrate various optical effects. Effects include colour combining and creating the illusion of movement. Certain black and white patterns on the upper surface of a top can even create the illusion of colour [2]. (This was first recorded by Fechner in 1838 and was later used with a top by a toymaker called CE Benham in 1894.) Templates shown in figure 4 are readily available on the internet [3]. Sets of coloured discs for colour mixing can also be found and printed. Books giving details of many of these patterns are also useful. Simple tops can be made using a redundant CD with a pencil as its point, and various patterns placed on top. Instructions are given elsewhere as well details of many discs producing different 'illusions' [4–6]. So whilst it is possible to use the spinning top to illustrate other things (which are not the primary aim of this article, but worth mentioning), it must be said that these things can be done because even the simplest top keeps spinning for a long time.

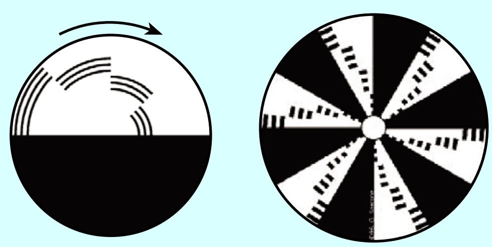

**Figure 4.** Fechner and Benham's disc patterns which produce the illusion of colour when spun.


**Figure 5.** Two Spintastics tops spinning alongside the long spinning Quirkle Quark.

Special well balanced tops exist with extra hard tips and spinning surfaces which spin for an extremely long time without additional input (figure 5); see for example www.quirkle.com/top.[1] Other tops that have been recently developed include those with internal bearings to reduce the small amount of friction that does exist and thereby increase the spinning time, enabling various clever feats to be performed. The great stability of the spinning top means they can often be thrown from one base to another without loss of spin. The ‘Spintastics’ company in America has a range of such tops and video demonstrations on its website, www.spintastics.com.[2]

More readily available is the neutron spin top (figure 6(a)). This interesting little top is capable of being tossed from one holder to another maintaining its spin. It is ‘powered’ with an integral electric motor in the top. A magnet in the holder which contains two 1.5 V cells, ensures good electrical contact is made, and once spinning this magnet is moved further from the base of the top so that the top can be thrown. Other toys which demonstrate the stability of the top are the ‘battle tops’ (figure 6(b)). Two tops, often with rough edges are spun on the same base. The idea is that they crash into each other and the winner is the last top spinning. Such tops can be purchased for a few pence or several pounds. For many their ‘battle top’ has become a serious hobby.

The levitron [7] is a small top which spins in mid air resting in a saucer shaped magnetic field. It keeps on spinning because so little energy is lost as it spins in the delicately shaped magnetic field above the base (figure 7). Details of how the levitron works can be found at www.levitron.com/physics.html, which includes a link to a levitron video. The only energy loss comes from the air in contact with the top as there is no solid point of contact. Its angular momentum gives it stability so that it does not topple over.

Other tops rely on a small input of energy at regular intervals to maintain their motion. The traditional whipping top is kept going because any losses are compensated by the occasional whip (figure 8). Whipping tops have been known for centuries all over the world, the earliest include references in Egypt 2000 BC, and in China in 1250 BC [8]. An American toy top known as ‘Top-No-Sis’ from Horizon Shine Toys [9], gains the small amount of energy necessary to keep it going from the tilting of the board on which it

[1] The Quark top, brass, from Quirkle ($49) is also produced with a tungsten tip ($149).

[2] Spintastics supplies tops, yoyos and diablos.

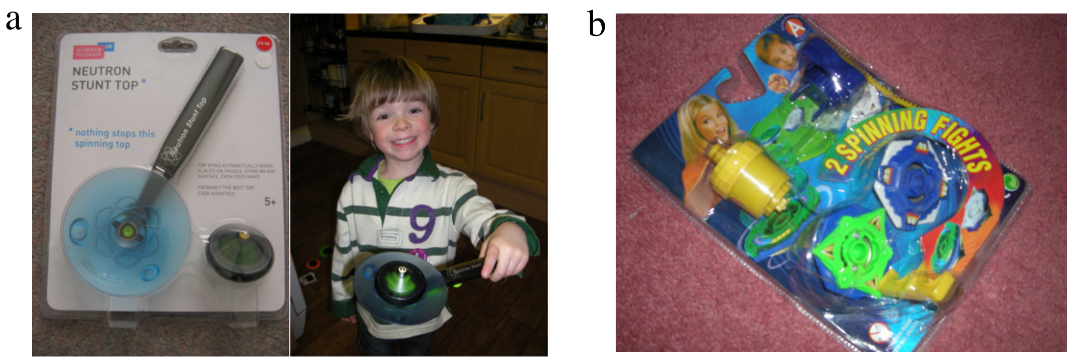


**Figure 6.** (a) The Neutron Stunt Top and (b) fighting tops, purchased from a toy shop.

**Figure 7.** The levitron.


**Figure 10.** The Gyro-Ring.

**Figure 8.** A whipping top.

spins (figure 9(a)). As the top moves downwards across the board it gains energy to compensate for any losses. The shape of the top is critical in performing this feat. The inventor, Ed Rubin, says that spun clockwise, a skilled player can make the spinning top travel in a counterclockwise direction indefinitely, though this claim may be a little exaggerated as the world record appears to be 2 h 52 min and 11 s! When the top travels around the board in the opposite direction to the spin, the speed generated can be large whereas when the top travels in the same direction as the rotation it will slip off on a tangent when it goes too fast. Clearly the cat is amused (figure 9(b)). There is a short video of this top on the Horizon Shine Toys website [9]. This idea of a tilting board and specially shaped top appears to have been copied more recently by 'Astrotopz' another US company.

An interesting toy called the 'Gyro-Ring' (figure 10), which consists of five ring tops strung on a larger metal ring. The small rings are spun and the larger metal ring is rotated in a vertical

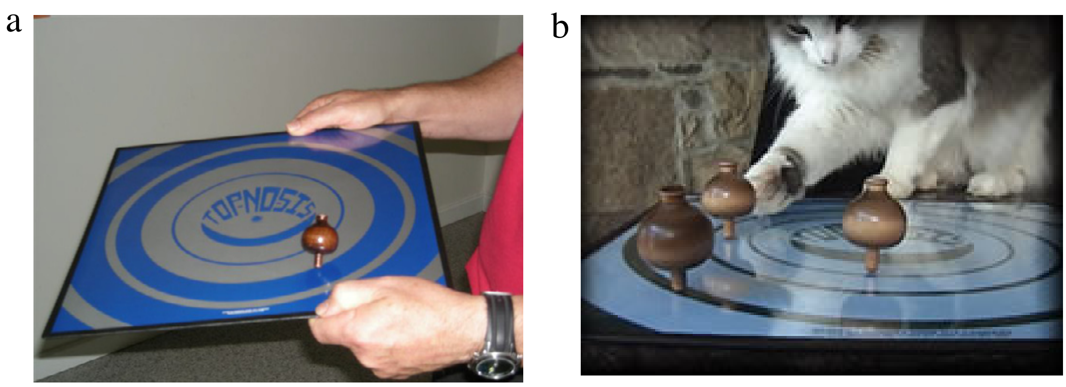


**Figure 9.** (a) and (b) Top-No-Sis.

**Figure 11.** Perpetual and long spinning tops.

**Figure 12.** Levitron with perpetuator.

plane. As the smaller rings fall relative to the metal ring, the metal ring presses on one side of them exerting a couple which is sufficient to increase the angular momentum of the small rings. It is quite a feat to get all five small ring tops rotating quickly at the same time.

As tops have such small energy losses these losses can be easily replaced. So-called perpetual tops provide this compensating energy with an offset vibrator powered by a small battery within the top [10, 11]. The magnetic long spinning top [12], also known as 'Top Secret', gains its compensating energy from an electromagnetic device contained in the black base. In this case the power source is hidden outside the top itself. The top has a radially oriented magnetic field and the base has a conducting coil. When the top spins past the centre of the box its changing magnetic field induces a current in the coil which momentarily opens the switch to the battery, switching on the electromagnet which delivers enough torque to the spinning to speed it up and spin away from the centre. These tops are shown in figure 11. A similar principle to that of 'Top Secret' is applied when using a perpetuator with a levitron (figure 12). The perpetuator is the black box which is placed beneath the apparatus.

There is of course a lot more to a top than simply low friction motion, for once something starts to spin fairly quickly, additional forces come into action if the axis of rotation is changed. A top therefore has a remarkable degree of stability as demonstrated by the bouncing top (figure 13). This has a small spring on which it balances and bounces. When dropped it bounces across

**Figure 13.** Bouncing top. The base is a spring.

a surface yet still maintains its spin as it goes. Tops which may appear to be falling over, can, if spinning fast enough, move back to the vertical.

Another surprising property is that 'top heavy' tops, or tops with a long axle will spin equally well either way up (figure 14).

This stability is also seen in the juggler's 'Chinese spinning plates'. Once the plates are spinning at speed on the tops of the rods they stay there, so that more and more can be set spinning. The stability of tops is also utilized in the many 'top tricks'; see for example videos at www.spintatstics.com referred to earlier. An interesting selection can be seen on YouTube

**Figure 14.** A long-spindled finger top, one of many from www.Arabesk.nl. This top may be spun as shown, or upside down on the long spindle.


**Figure 15.** Examples of rocket footballs. The fins cause the ball to spin when thrown.

(Spinning Top Circus) as a top enthusiast shows off his collection, although by just searching YouTube for 'tops' many interesting sites will be found. The length of spin is increased by having a smooth hard surface. Such bases are available commercially, but far better to improvise using mirrors, CD cases, plates, fruit bowls, upturned frisbees etc.

Other objects which are spinning also exhibit this stability when thrown. Children are familiar with various frisbees and throwing rings, and we have all thrown a flat spinning stone across a lake and watched it bounce on the surface of the water. It bounces because of its shape and the surface tension on the water, but its stability is accounted for because it is spinning. Spinning objects travel further because of their stability. Several recently introduced sports 'balls' and throwing toys utilize this fact, by having fins which produce spin as they are thrown. An example is the rocket footballs shown in figure 15.

Many effects of angular momentum can be demonstrated using a simple gyroscope, the play thing of most children in the 1950s. A gyroscope on a moving platform can demonstrate the way in which a spinning object conserves its spin as used in navigation. It can show clearly how precession can occur and moving the gyroscope around in one's hand enables various forces to be observed.

When a gyroscope (figure 16) or spinning top slows and begins to lean over from the vertical, the gravitational force downwards due to its weight leads to a couple which causes precessional rotation around the original vertical axis of the gyroscope (see appendix). Students at higher levels will be familiar with three actions at right angles (Flemings left-hand rule, or vector products) so this should not present too great an intellectual leap! In this case however, it is the three rotations or turns which are at right angles. Analysis of precession by defining vectors appropriate to 'spin' and then combining them in terms of a 'right-hand rule' is described in papers from the Electrical Engineering Training Series (www.tpub.com/neets/book15/63b.htm) and shown in figure 17.

This conservation of spin or of angular momentum is significant in maintaining balance on a moving bicycle. A disc, bicycle wheel, or tyre will readily topple when stationary, but has a remarkable stability when rolled along. Once the wheel has significant 'spin', additional forces are needed to make it fall over because the spin's plane has to be changed. It is difficult to balance on a bicycle if the wheels are not rotating, yet when moving along, the bicycle balances without additional effort. The simplest demonstration of this would be a hoop and stick, a toy from Victorian times or earlier. Everyone, including those with little scientific background know that the hoop falls over if stationary, but as soon as it starts rolling it stays upright. How many appreciate the physics behind this amazing phenomenon, will be a different storey.

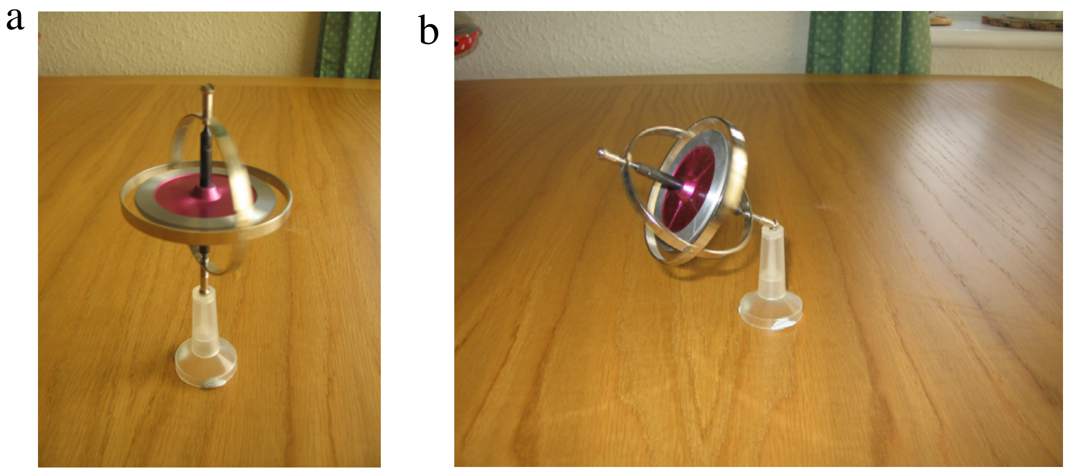


**Figure 16.** (a) Gyroscope. As the gyroscope slows it processes (b).

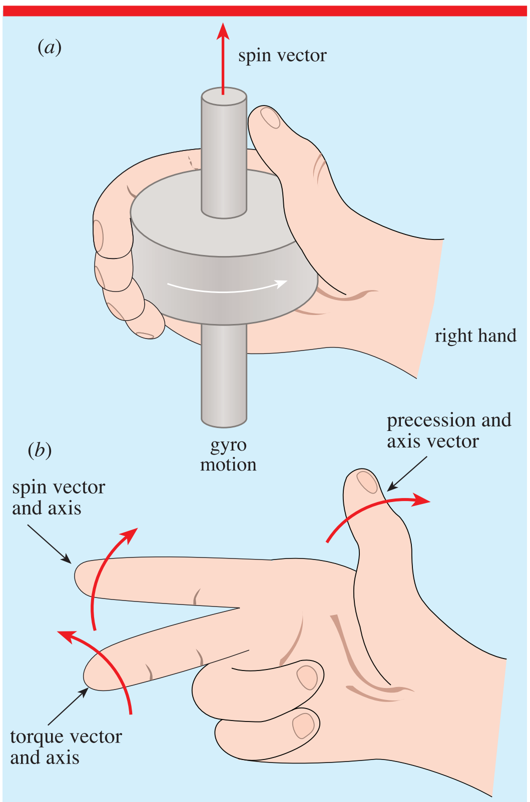


**Figure 17.** (*a*) The right-hand grip rule for the direction of the spin vector. (*b*) The right-hand rule for the direction of the precession vector.


**Figure 18.** The power ball.

The electric gyroscope toy (which contains an internal wheel powered by a battery and motor) (shown in figure 18) can give students an experience of the couple needed to turn a rotating body, as can the recently introduced roller ball, or exercise gyro (figure 20). This is also marketed under the name 'power ball', with added electronics to measure the rate of spin. A relatively heavy ball is rotated inside the hand-held roller ball, and twisting it in the hand is said to offer a strengthening exercise for the wrist. This couple (resisting change of direction) can also be felt using household electrical equipment with rotating parts, providing due attention is paid to safety. For example, you can compare the forces moving a hand-held electric mixer or power drill, when switched off and when rotating. Edmund Scientific have produced an interesting piece of kit consisting of a gyroscope mounted inside a cylinder, called the gyro tube (figure 19). When the gyroscope is not spinning the cylinder can

**Figure 19.** Gyro tube from Edmund Scientific.


**Figure 20.** Internal gyro tops (electric, Whirlwind, and light spinner).

easily be rolled smooth, but when the gyroscope is spinning the cylinder does not roll freely.

The electric gyroscope is an example of a top with an internal (often hidden) rotating wheel. This does mean they can be handled safely without touching any moving parts. A selection of tops with internal gyros is shown in figure 20. The electric gyroscope's wheel is powered by batteries and a motor, the second 'turbo top' [13] also known as 'Whirlwind' is given its angular momentum by blowing through small holes in the side which sets the internal gyro rotating. The third [14] is set rotating mechanically, by rolling the base ball which is connected to the axis of its internal gyro wheel.

The forces that these tops display are well known to children and therefore should also be experienced and discussed in school. Just holding an object containing a rotating disc or wheel can be adequate to demonstrate that there are additional torques to contend with. In addition to turning the object as a whole, torque is required to change the direction of the angular momentum and this is what we feel.

The moment of inertia of a body describes the way in which its mass is distributed around a rotating axis. Applications abound showing how the moment of inertia and the conservation of angular momentum are related. All children have watched ice skaters or high board divers increase their rotational frequency by moving their arms inwards. A slow rotation is increased as the distribution of mass is concentrated towards the axis of rotation, i.e. the moment of inertia is decreased. This is clearly shown in several examples on 'YouTube', for example Natalia Kanounnikova's YouTube movie showing her reaching the world record for an ice skating spin of 308 rpm (www.youtube.com/watch?v=AQLtcEAG9v0).

Examining the motion of a trampolinist or gymnast clearly shows how the athlete uses variations in mass distribution to change the rate of rotation. A high board diver also utilizes this principle as he/she takes off and falls, rotating and extending to enter the water with minimal splash. As the diver's moment of inertia is decreased by adopting more compact positions, the diver is able to produce more turns before reaching the water.

A great experiment that children (and adults) enjoy is to utilize a freely rotating platform to demonstrate the conservation of angular momentum. Whilst this can be done with a rotating office chair, it is far better to use a platform on which the pupil can stand. Such a platform can be purchased[3] or constructed using the parts of an old skateboard. Holding large masses or dumbbells greatly increases the effect. Pupils can experiment with different weights and different rates of rotation. It is also possible to buy a freely rotating stool on which these experiments can be performed[4]. The boy on the platform has a high moment of inertia as he rotates slowly (figure 21(a)) but when he pulls the weights to the centre of his body the moment of inertia is reduced and to keep angular momentum the same

[3] Gyroscope wheel from 3B Scientific, Pasco, or other science equipment suppliers.
[4] Rotating platform from 3B Scientific, Pasco, or other science equipment suppliers.

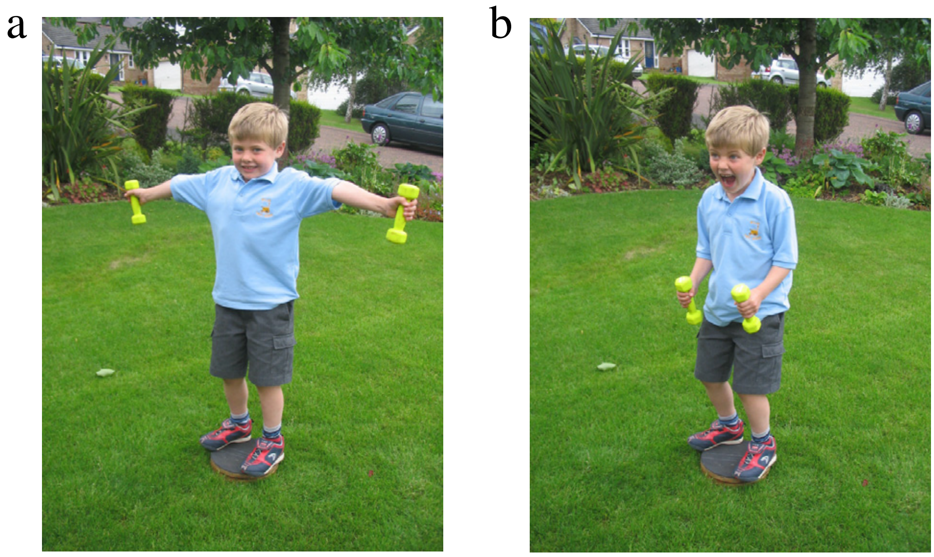


**Figure 21.** Changing mass distribution on freely rotating platform. (a) Slow rotation, large moment of inertia. (b) Fast rotation, small moment of inertia.

his angular speed increases, much to his delight (figure 21(b)).

If a toy top with significant moment of inertia can be set spinning with its axis horizontal, it stays horizontal. The couple due to gravity leads to precession of the top in a horizontal plane. It rotates horizontally rather than falling over. Many of us might be content with simply spinning the top on the floor. It was Hugh Hunt of Cambridge University who suggested in a recent lecture, which partly inspired this article, that toy tops should be supplied with a piece of string so that they could be spun with their axis horizontal (figure 22).

A similar experiment can also be performed with a bicycle wheel on a BMX peg. Versions of this are supplied by several scientific outlets, boasting better bearings and hence longer spin than the average bicycle wheel (at a price)[5].

Too often toy manufacturers will refer to these effects as mysterious or magical. Maybe what they actually mean is simply that *they* do not understand them. Tops which are spinning are claimed to 'defy gravity'. If that is so, then so does a chair. These days anything with a 'wow' factor seems to be called magical. Certainly 'spin' effects fall into this so-called 'magical' category as many of the effects are counterintuitive. As more basic physics disappears from our school syllabuses it seems that more and more becomes magical. Let us keep the sense of wonder, but maintain that physics enables us to understand the 'wow'.

It is well known that cats falling vertically land on their feet. By manipulating the two ends

**Figure 22.** Something more to do with your toy top or bicycle wheel. Note the orientation of the top on the string.

[5] Rotating stool from Pasco.

**Figure 23.** The author controlling rotation on a freely rotating platform in his garden with a gyroscope wheel (from a wheelbarrow).

**Figure 24.** Using a commercially available gyroscope wheel from Pasco and rotating stool to demonstrate conservation of angular momentum.

of its body separately the cat is able to land feet first. This is clearly described in *Superstrings and Other Things* by C I Calle [3]. One wonders how this has become a innate feature of all cats. Did they in the past keep falling out of trees and only those who landed the right way up survive? If so, why is it that they nowadays get stuck up trees and need someone on a ladder to retrieve them, when simply falling off the branch would be a safe option, as they have an inborn intuitive ability to land the right way up. Maybe high board divers could take a few lessons.

One step further is to experiment with a rotating wheel on freely rotating platform, which enables the experimenter to adjust direction (figures 23 and 24). Students are usually enthralled with the ability to control motion of the platform using the rotating hand held wheel/gyroscope, rotating first one way then the other as the wheel is moved. Using a specially constructed platform in conjunction with a rotating heavy wheel leads to all kinds of interesting effects. Pasco supply both the wheel and a rotating stool, with particularly frictionless bearings, though the cost of the pair will put it out of reach of many schools who will prefer the home made version with parts from an old bicycle wheel and skateboard. A rotating platform is available from 3B Scientific for only £38 though the bearings of the Pasco stool model are vastly superior. This controlling effect is utilized in space travel to change the direction of crafts—something similar has been used in the Hubble telescope to change its direction.

No discourse on tops would be complete without a final reference to the renowned tippee top [15] which has amused physicists down the years (figure 25). An interesting photograph showing Wolfgang Pauli and Niels Bohr observing the tippee top [16] by Gustafson, can be found in the AIP Emilio Segre Visual Archives (www.aip.org/history/esva). This top has a rounded point of contact so that friction is significant and its centre of mass is lower than the centre of curvature of the base. These two factors produces a couple which remarkably inverts the top (another example of three turning vectors at right angles). The tippee top also reverses its spin (relative to the top itself) but not to the outside observer. There is a huge range of such tops available for many suppliers, my favourite for variety being Arabesk in the Netherlands [17], though the extra large wooden version from Arbour Science [18] takes some beating. Another of my favourites is the double action tippee top originally from Hawkin,

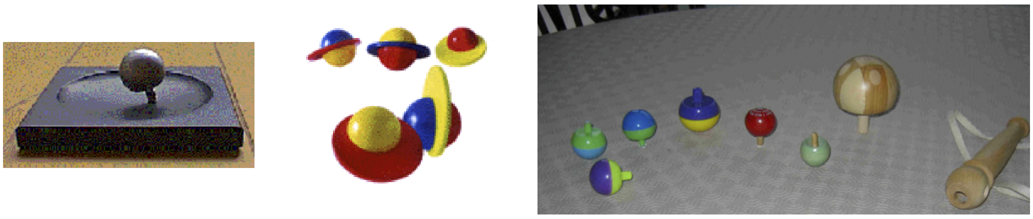

**Figure 25.** A selection of tippee tops from Arabesk and Arbour Science.

**Figure 26.** Two different rattlebacks or celts.

but now no longer available in the UK, in which a small point protrudes from the base making the upturn impossible, however this tip can easily be pushed inside the base, returning the top to its tippee status. Chocolate cream eggs and certain other sweets can also be spun horizontally in a way that causes them to turn up on their ends too.

The celt or rattleback [19, 20] is in a way also a top (figure 26). This is alleged to have originated as a simple stone (maybe in Australia) which when spun had a preferred direction of rotation. If spun in the opposite direction it would stop, due to an opposite couple caused by its geometrical shape and mass distribution. It was thought to possess magical properties, but of course we know it is simply a case of physical principles which those who observed it did not understand.

Whether or not rotational motion is on the syllabus of your physics course, it certainly does figure in everyone's everyday experience, but the wow and wonder it can generate from a young age should mean that teachers should be familiar with their basic principles, be able to discuss their motion and enjoy the wonder with our children. We might even start our own collection or develop the skills to perform many fascinating tricks.

## Appendix. Precession

A rapidly spinning top will precess in a direction determined by the torque exerted by its weight. As the top begins to fall over it rotates in a conical path, i.e. its top end slowly revolves about the vertical direction. This additional rotation to the spin of the top itself is known as precession. The direction of the precession is determined by the sense of rotation of the top and direction of the couple acting. The precession is faster and more noticeable as the top slows down. See, for example, http://hyperphysics.phy-astr.gsu.edu/hbase/top.html or any classical mechanics textbook. The three finger rule is explained clearly in www.tpub.com/neets/book15/63b.htm.

Whilst a top's precession is noticeable, it must be noted that the Earth also has a precession, but with a huge period—25 920 years.

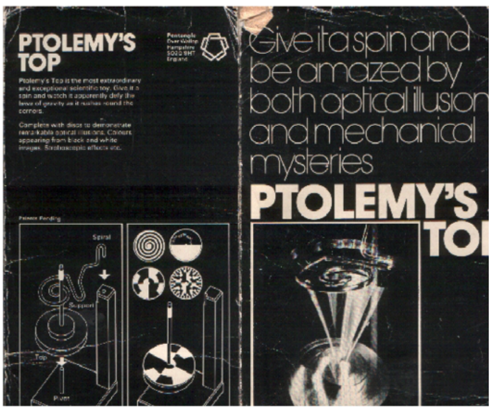


**Figure A.1.** Ptolomy's top.

An interesting variation is found in Ptolomy's top (figure A.1) whose centre of mass is below the pivot, thus the top is in stable equilibrium. When it leans over the couple tends to restore it to the vertical position, and it precesses in the opposite sense to that of a conventional top. Sadly after my own Ptolomy disappeared from a cupboard in my old school, I have been unable to obtain a replacement.

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## References

[1] The *Iliad* by Homer in XIV 413 in 800 BC claims to be a story of the fall of Troy. '... reels like a top staggering to its last turnings.' Taken from [8].
[2] References from Shakespeare (1564–1616):
*Merry Wives of Windsor* V.i.27 (1601) '... played truant, and whipped top'
*Winter's Tale* II.I.103 '... not big enough to bear a school boy's top'
*Coriolanus* I.Ix.24 '... turned me about with his fingers and thumb, as one would set up a top'
*Twelfth Night* I.Iiii.44 '... turn o' the toe like a parish-top'. Taken from [8] .
[3] See, for example, Calle C I 2001 *Superstrings and Other Things* (Bristol: Institute of Physics Publishing) pp 102–7 (ISBN 0-7503-0707-2)
[4] www.michaelback.de/ot/col_benham/index.html (Benham top)
Instructions to make discs and tops at www.archimedes-lab.org/workshoptop.htm
[5] Coloured discs to download www.msm.cam.ac.uk/seek/beams.htm
www.colour-experience.org/flying/flycol_illusion
[6] Armstrong T 1991 *Colour Perception* (Tarquin) (ISBN 0-906212-74-X)
Kremer J 1992 *Turntable Illusions* (Fairfield, IA: Open Horizons) (ISBN 0-912411-37-6)
[7] Simon M D 1997 Spin stabalized magnetic levitation *Am. J. Phys.* **65** 286–92
[8] Oliver V 2002 *History of the Spinning Top* www.spintastics.com
[9] www.horizonshinetoys.com/photo_and_video_gallery.html
Astrotopz from www.astrotopz.com
[10] Perpetual top from Educational Innovations www.teacherscource.com
[11] Non-stop spinning top from Hawkin www.hawkin.co.uk
[12] Top Secret from www.Arabesk.nl
[13] Turbo top from Hawkin www.hawkin.co.uk
[14] Flashing light spinner from Happy Days, Keswick, UK www.happydays.co.uk
[15] Tippee top: Cohen R J 1977 Tippee top revisited *Am. J. Phys.* **45** 12–17
Inverting spinning top: www.teachersource/physics/gyroscopesandtops/invertingpoptops.aspx has a video of the top
For a discussion on the theory: www.me598.wikidot.com/an-investigation-of-the-tippe-top
[16] Gustafson E *Margrethe Bohr Collection* courtesy AIP Emilio Segre Visual Archives (www.aip.org/history/esva)
[17] Arabesk tops from www.arabesk.nl
[18] www.arborsci.com
[19] Rattleback: Walker J 1979 The mysterious rattleback *Sci. Am.* **250** 172
[20] From www.arabesk.nl or other suppliers

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