MANCHESTER 1824
The University of Manchester

Challenge Title: Spinning top challenge	**Duration:** 20 minutes
Short Description: Learners will be asked to make their own spinning tops. Based on the principals of the conservation of angular momentum and the gyroscopic effect the learners will be asked to make the best spinning top possible. They will be asked to spin their tops at the end of the workshop with the one that spins for the longest winning a prize.	
Venue: Classroom	
Number of Participants: Up to 25	**Year Group:** 9
Resources: • Pencils • Tape • 2 rubber bands • Cereal box-weight cardboard • Pennies (6 per group) • Scissors • Markers • Stopwatches	**Health and Safety guidance:** *(e.g. gloves, allergy information)*
Challenge context: *(What background knowledge do participants need?)* Basic understanding of angular momentum/velocity and the gyroscopic effect.	

Instructions:

1. Draw three circles on cardboard by tracing around a circular object. Cut them out.
2. Poke a pencil through the middle of one of the cardboard circles. Hold it firmly in place by winding rubber bands around the pencil above and below the cardboard.
3. Secure the cardboard shape where you want it on the pencil (axis of rotation) by winding rubber bands onto the pencil above and below the location. The students should decide where the cardboard shape should be to achieve the optimal performance.
4. With a marker, draw a line at any point on the cardboard spinner top. Have the students spin the spinner. Count the number of rotations the spinner makes within 10 seconds. Write this number down. (The line must be very dark to be able to read it while the shape is spinning.)
5. Now tape six pennies onto the outer rim of one spinner, and six pennies close to the centre of another spinner.
6. Repeat Step 4 with both of these spinners. Has the number of rotations completed within 10 seconds changed? If so why? (Conservation of angular momentum dictates that the spinner with the pennies at the outer rim should spin slower)
7. Allow the students to optimise their design based on their findings.
8. Have all the students spin their tops at the same time and see who's spins for longest.

Plenary *(Summary of what students have learnt)*
Students should have an understanding of conservation of angular momentum and the gyroscopic effect. The differing performance of the gyroscopes depending on their weight and the location of mass demonstrates these effects. Students should be more aware of the importance of these effects in every day life. e.g. satellites spin to stabilise their flight, the distance between the Earth and the Moon is increasing due to conservation of angular momentum.

Further Reading

Information on workshop and further ideas:

http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_mechanics/cub_mechanics_lesson08_activity1.xml

General info:

http://en.wikipedia.org/wiki/Gyroscope

http://en.wikipedia.org/wiki/Angular_momentum

http://en.wikipedia.org/wiki/Precession

http://hyperphysics.phy-astr.gsu.edu/hbase/mechanics/bicycle.html

Flying gyroscope instructions:

http://www.instructables.com/id/Flying-gyroscope-out-of-a-single-sheet-of-paper!!/

Useful equations:

- Angular momentum = radius x linear momentum

  = radius x mass x velocity

  i.e. $\mathbf{L} = \mathbf{r} \times \mathbf{p} = \mathbf{r} \times m\mathbf{v}$
- Torque = Angular velocity of precession x angular momentum

  i.e. $\boldsymbol{\tau} = \boldsymbol{\Omega}_{\mathbf{P}} \times \mathbf{L}$

Interesting fact:

The Moon is slowly moving further away from the Earth. This is because the Earth's rotation is slowing down due to drag submitted on it by the Oceans. In order to conserve momentum within the system the Moon must orbit further away from the Earth.

Satellites are designed to spin as they fly around the Earth in order to stabilise their flight and therefore ensure they keep on course and don't fall to Earth.

Modern uses: Since gyroscopes allow the calculation of orientation and rotation, designers have incorporated them into modern technology. Products including the new iPhones and the Nintendo Wii controllers use gyroscopes in order to gain accurate recognition of movement.

About the author

My name is Huw Woodward and I'm a postgraduate student at the University of Manchester. I graduated at the University with a degree in Mechanical Engineering and I am now doing a PhD in computational modelling of fracture mechanics. I always enjoyed physics in school and found it particularly interesting when theory was applied to solve practical, everyday problems, which is what engineering is all about!

In my spare time I enjoy socialising with my friends, playing football and generally keeping fit and healthy!