

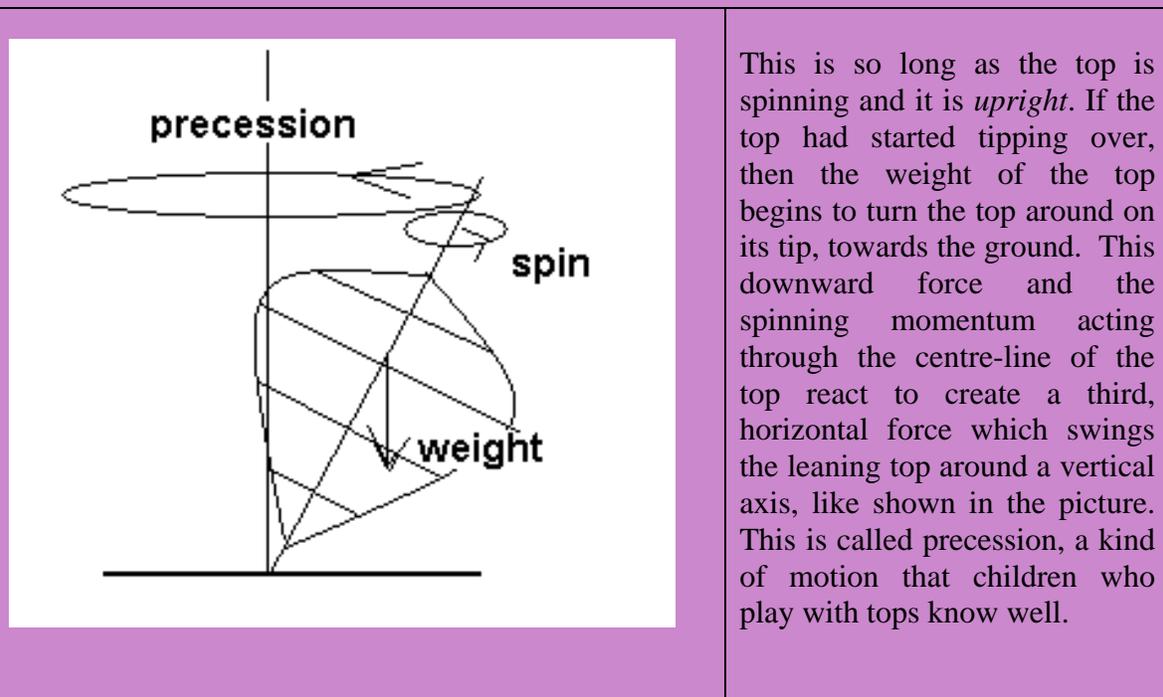
## Planet earth wobbles while it whirls

A recent news item raised an alarm of changes in the earth's *angle of tilt* leading to climate changes, says S.Ananthanarayanan.

Some readers wondered whether the earth could change its orientation in space by itself. Would such a thing not violate the rules of physics? The answer lies in the dynamics of a spinning body in the gravity of the sun and moon.

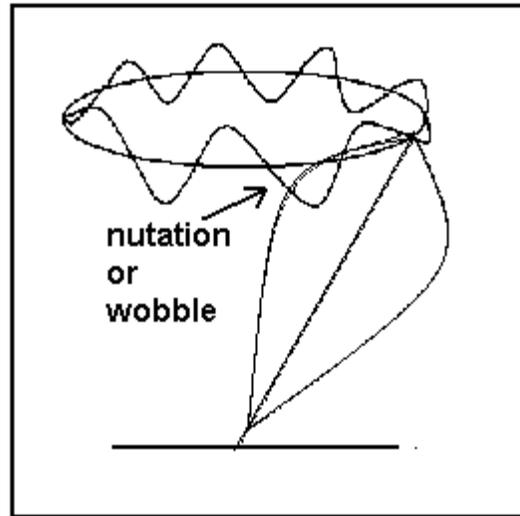
### The motion of a top

A child's top, if placed upright on the ground, would topple over. But when the top is imparted *spin*, the spinning momentum, which is along the axis of spin, keeps the top from falling. The reason is that the upright axis contains the energy that it took to start the spin. If the axis is now to change from upright to another direction, it is not just a stationary top turning over – the motion of all the parts of the top, which are whirring around, needs to be altered.

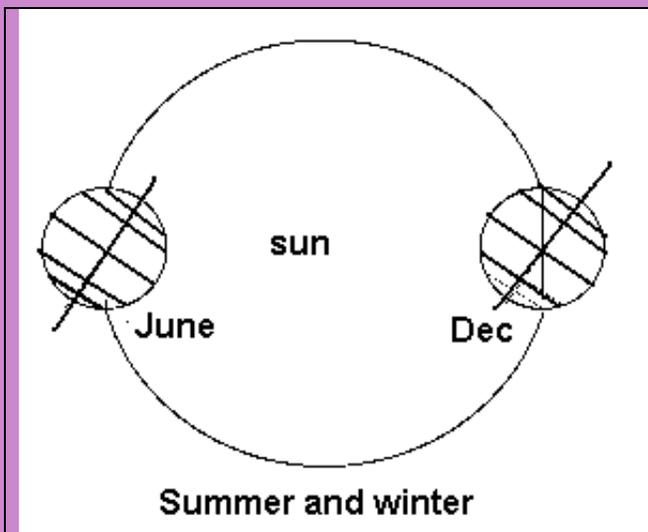


## Nutation

As precession sets in, yet another effect, nutation gets going. Like a downward force leads to a sideways motion, precession leads to a force that pushes the top upwards when it begins to dip. And when the top begins to rise, the rate of precession slows, which reduces the nutation force and the top dips again, and so on.



## The earth and seasons



We know that why we have the seasons is that the spinning earth turns different hemispheres to the sun at different times in the year. This happens because the axis of the earth's spin is inclined to the face it shows to the sun as it goes round. Thus, in June, the northern hemisphere is warmest and in December, it is the south that is warmest, like in the picture. We can see that if the angle of tilt were less, then the weather would be more uniform and if the tilt were more, then the winters and summers would be more severe.

### **Does the tilt change?**

The spinning earth, like the child's top, steadily points the same way, the year through, although the spin is slow indeed, just once round in 24 hours. Also, although the axis of spin being 'at an angle', the sun's gravity does not affect the earth's motion quite like a top because the earth is not on a table top or mounted on a spindle. But because the spinning motion has made the earth slightly wider about the equator (like many of us), the gravity of the sun and the moon (not to talk of other planets) do affect the earth differently at different points. The result is that the north-south axis of spin of the earth also swings around, just like the many tops that children play with on the earth's surface.

The rate of swing is very slow too – just once round in 25,800 years. And we can see that the only, but great effect this would have is that the time of summer and winter would interchange once in 12,900 years, or half the time of full turn-round. The summers and winters would not get any more or less severe.

### **Another motion**

Apart from precession of the axis, another top-like motion of the earth is that the angle of tilt also moves up and down. This motion, caused by the combination of spin, precession and the gravity of the sun, moon and other planets, is slighter and slower still – just between  $21.5^\circ$  and  $25.6^\circ$ , once in 41,000 years.

### **The ice ages**

Scientists believe that it was this effect, towards  $25.6^\circ$ , that has brought on the ice ages, when the polar ice caps grew and covered much of the landmass. The ice ages show a period of 40, 80 or 120 years – as if to follow the cycle of the earth's tilt, sometimes needing more than one cycle to switch from glaciation to thaw or the other way round.

But the effect is too gradual to significantly affect the 'global warming' that environmentalists take interest in. In any case, the present state of the earth's tilt is towards the next ice age, some thousands of years away, not a meltdown.

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