29.4: Gyroscopes and Gyrocompasses in Navigation

A gyroscope is a fast-spinning disc supported in such a way that there is no external torque, except an occasional boost to keep up its speed (jet of air, or magnetic). Since there is no external torque, it always points the same way. A device based on this principle and used in aircraft is termed a heading indicator.

Suppose the gyroscope is set spinning about an initially vertical axis. If it's nighttime, this means its axis is pointing to a particular star, overhead at that moment. It will continue to point to that star, so, unless you're at the North or South Pole, the axis will move from the local vertical to return 24 hours later. Since the direction of the gyroscope axis is fixed in space, and the Earth's axis of rotation is fixed in space, the angle between the two is obviously constant, so as seen in the lab, say, the gyroscope axis describes a cone about a line parallel to the axis (the line a sundial pointer points along, vertical at the North Pole (so the gyro doesn't change) down to horizontal at the Equator.

This is useful, but it would be better to have a pointer that just points North (or South). This is achieved by damping the gyroscopes motion—put one end in viscous liquid. Then, when it moves relative to its container, there is a couple opposing the motion. What this does is move it inwards, relative to its cone of motion, that is, the cone shrinks, so it goes to a stable orientation parallel to the Earth's axis, that is, it points North (or South).

A gyrocompass is the same idea, but now constrained to lie in a horizontal plane. This plus some damping forces the compass to orient as close to the Earth's axis as possible in the horizontal plane, meaning it points North, in this hemisphere.