Simultaneous recording of gyroscope precession and nutation using one or two wireless sensors

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The mechanics part of our first year BSc course *Mechanics and Relativity* not only contains lectures and tutorials, but also two practicals of two hours each. These practicals, of which one concerns the gyroscope, are somewhat classical in the sense that they reinforce concepts discussed before in the accompanying lectures. They also continue the practical skills learning line of the first year BSc programmes of Physics, Applied Physics and Astronomy.

The gyroscope practical has been part of the course for a long time and in the past both precession and nutation were studied by students by observing the gyroscope's motions and timing the periods of both phenomena manually with a stopwatch. The theory section of the manual also describes both phenomena. For various reasons the contents of the course has changed slightly and currently precession is still being taught in the lectures, but nutation not anymore. The duration of the practical has also been reduced from three to two hours. Therefore nutation is not an official part of the practical anymore. But since nutation can often be observed simultaneously with precession when using a laboratory gyroscope, it may still be of interest to students. And by using a wireless rotational sensor mounted on the gyroscope, the effect of nutation is easily determined while measuring precession. Last year a wireless sensor was introduced to determine precession frequency and its use was optional then, but a very large majority of the students already preferred its use over the stopwatch method. Therefore using the wireless sensor is now mandatory.

The wireless sensor module (Texas Instruments SensorTag CC2650) is mounted on the vertical rotation axis of the gyroscope (see Fig. 1). This module contains (among others) a rotational sensor and communicates with the phyphox app via Bluetooth. If nutation is absent, the recorded angular velocity ω around the vertical axis is constant and equals the precession frequency Ω_{pre} of the gyroscope. If nutation is present as well, this will result in a sinusoidal variation of ω around its average value Ω_{pre}. The period of this oscillation then equals the nutation period T_{nut} of the gyroscope. Therefore students can derive information about both precession and nutation from a single measurement. Optionally a second sensor module can be mounted on the rotor axis to perform more measurements on nutation. Data from both sensor modules can be acquired simultaneously with a separate phyphox experiment.

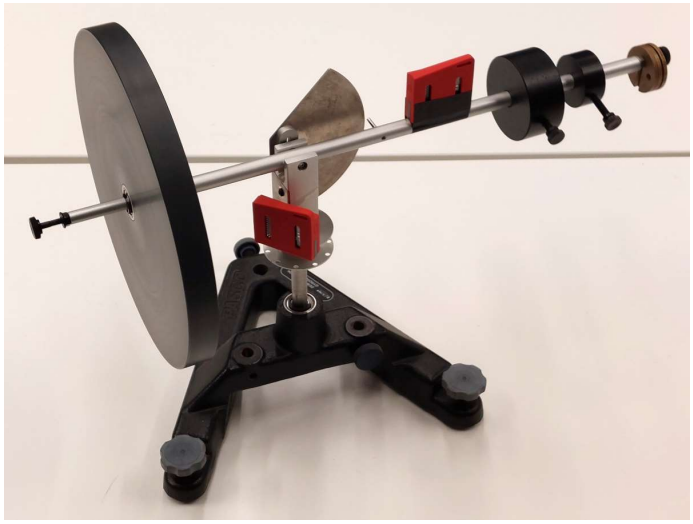

Fig. 1. Gyroscope with rotor disc and counter weights. The wireless sensor modules (red) are mounted on the vertical rotation axis (left, mandatory for students) and on the rotor axis (right, optional).