

THE GYROSCOPE (FREELY MOVING)

MED 09.18b



Material

Item-no.	Qty.	Description
DM354-1K	1	Gyroscope, complete set

THE GYROSCOPE (FREELY MOVING)

MED 09.18b

General properties of a freely-moving gyroscope

A freely moving gyroscope is a symmetrical gyroscope that is mounted or suspended in such a way that no forces can act on it. There are two ways to implement such a force-free mounting or suspension. On one hand the mounting of a specially shaped top in the center of gravity and on the other hand the gimbal suspension of a top. Our top has a gimbal suspension.

In the accessories there is a Y-piece with ball bearing, with the help of this the gyroscope can be gimballed, i.e. without force, to show the properties of a freely moving gyroscope.

Experiment 1

Insert the Y-piece in the round base; afterwards set the gyroscope into motion (explanation in the previous experiment) and place it on the Y-piece.

Now the complete unit (base + Y-piece + gyroscope) is taken by its base and moved through the room -

all possible translational and rotational movements can be made with the suspension.

Result

The gyroscope axis will maintain its position or direction in space with all spatial changes of the suspension.

Note

When carrying out this experiment it should be taken into account that the bearings do not work smoothly, of course. The bearing in the middle of the Y-suspension is a double ball bearing, but in some special positions it has a relatively large amount of friction. This is particularly the case when the axis of this bearing is extremely inclined and the entire weight of the gyroscope "hangs on this double ball bearing". To make sure that these friction effects only slightly disturb the demonstration of the free gyroscope, you can do the following:

Only move very slowly and evenly when moving the suspension.

Movements in which the gyro axis points briefly in the same direction as the axis of rotation of the plastic bearing on the Y suspension should be avoided.

Physically speaking:

Like most gyroscope phenomena, this property of the freely moving gyroscope is based on the preservation of the angular momentum in a closed system. Due to the special force-free suspension the gyroscope can be regarded as a closed system in this case. The angular momentum is a vector quantity - it has magnitude and direction. If the angular momentum is retained, then of course its magnitude and direction is also retained. This results directly in maintaining the axis direction of the gyro when changing the suspension.

THE GYROSCOPE (FREELY MOVING)

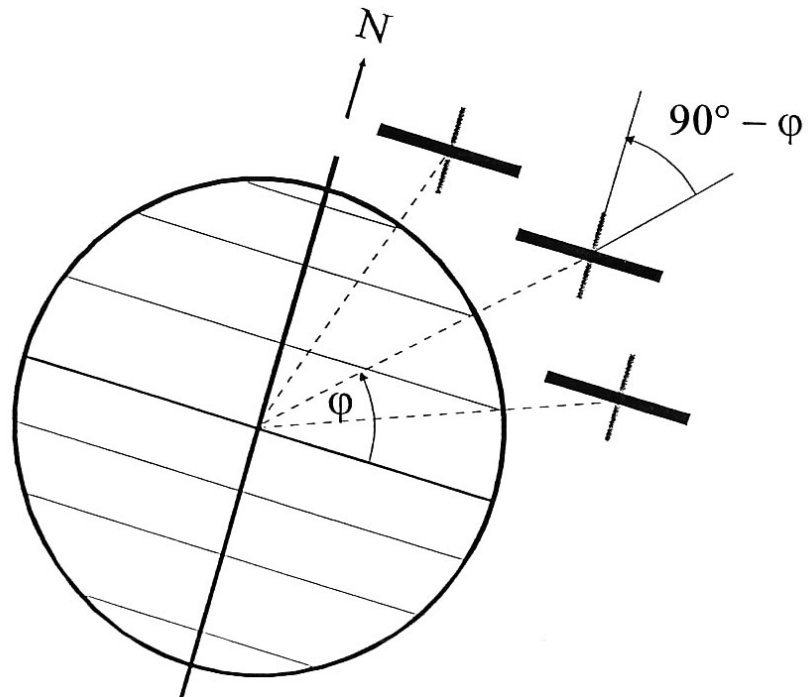
MED 09.18b

Experiment 2 – determining the latitude

After the gyroscope has been set in rotation the gyroscope axis is set so that it is parallel to the earth/globe axis. The respective geographical latitude can now be determined with a plumb line and the freely moving gyroscope.

The plumb line forms an angle ($90^\circ - \varphi$) with the gyroscope axis if the gyroscope (the centre of gravity of the gyroscope) is in the geographic latitude φ .

This relationship is shown graphically in the following drawing.



Application

This property of the freely moving gyroscope is indispensable in shipping and air traffic. A so-called gyroscope compass contains a freely moving gyroscope - similar to the gyroscope described in our experiment. In addition there are a lot of other mechanical parts in such a gyroscope compass, but they only serve the better and more precise technical implementation of the freely moving gyroscope. In principle, a gyroscope compass works exactly in the way that is shown in the experiment. Often a device is also integrated that enables the direct reading of the latitude.

One question remains: How can you set the gyroscope axis (especially with a closed compass housing) exactly parallel to the earth axis?

This question can be answered easily if you think about the conservation of angular momentum. As mentioned at the beginning, the angular momentum is retained in a closed system. The gyroscope or the gyroscope compass cannot be considered as a closed system here because its suspension is connected to the earth (which is a rotating reference system).

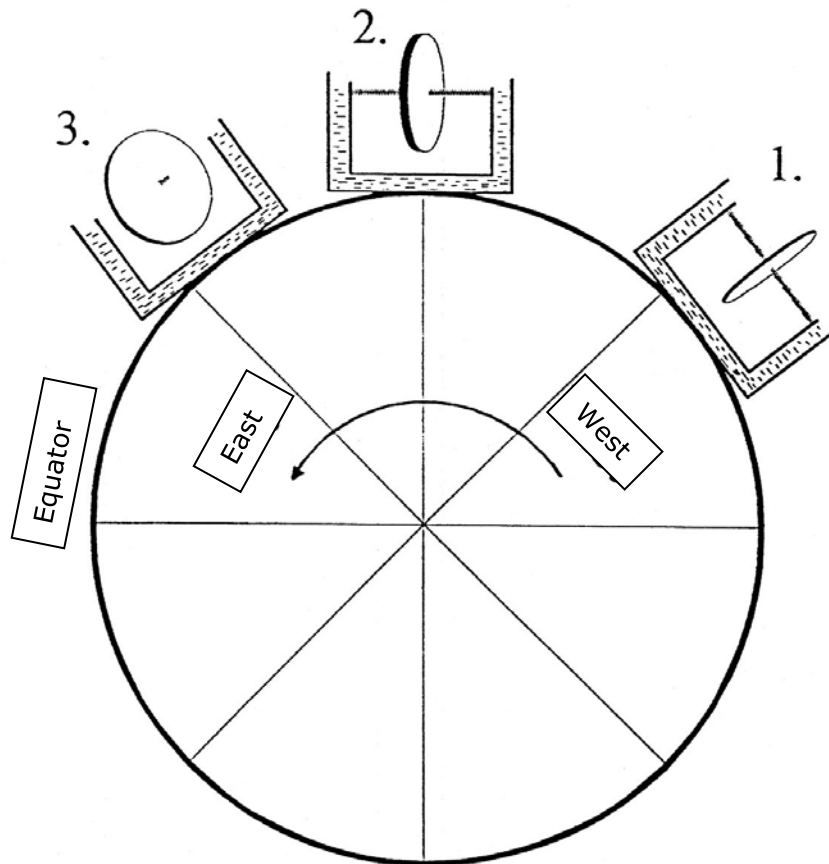
The rotation of the earth must have an effect on the behavior of the gyroscope. These effects result in a rather astonishing property of a correspondingly positioned freely moving gyroscope in the Earth reference system: The gyroscope automatically adjusts itself so that its axis is parallel to the earth's axis. Once the gyroscope has been set up in this way it remains unchanged in this position. This means that the gyroscope compass calibrates itself or sets itself correctly.

THE GYROSCOPE (FREELY MOVING)

MED 09.18b

Physically speaking:

The following drawing explains why the gyroscope in a gyroscope compass in the Earth reference system aligns itself so that its axis is parallel to the Earth's axis.



The gyroscope is mounted with its axis in a swimmer so that its axis is always aligned horizontally.

1. The gyroscope axis is aligned to the equator in a west-east position.
2. After a certain time the gyroscope axis is tilted by the earth's rotation. Due to the precession movement of the gyroscope (compare Experiment 2), the axis direction changes normally to the direction in which the axis should turn.
3. Due to the ongoing process described in the 2nd experiment the gyroscope comes once in the position in which the gyro axis is parallel to the earth's axis. Once in this position, the direction of the gyroscope axis no longer changing since there is no more torque that tilts the axis of rotation.