

DBF Dayanand College of Arts and Science, Solapur

Department of Physics

Presented by: Dr. R. N. Mulik



Dayanand **E** **Physics**
Pathshala

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SUBJECT	PHYSICS
PAPER NO & TITLE	Paper - V General Physics, Heat and Sound
MODULE TAG	DAYA_PHY_RNM_M1

PHYSICS

General Physics, Heat and Sound
Class: B.Sc. II (Semester: III) Date: 23rd July 2020

Module.1: Precession and Gyroscope

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Module.1: Precession and Gyroscope

1. Learning Outcomes

- In this module,
 - You shall learn about the information of precessional motion and torque.
 - You shall learn about Gyroscope
 - You shall learn about relation between gravitational torque and gyroscopic motion
 - You shall learn about Application of Gyroscope and Precessional Motion

1.1 Introduction

- Working of gyrocompass for navigation of ships and aeroplanes, directional stability of firing bullet etc., the principle of precessional motion is employed.
- To study the precessional motion, plane vectors is essential.
- The physical quantities like velocity, acceleration, force etc. can be represented by vectors called as linear vectors.
- Rotational dynamics, are represented by plane vectors.
- A plane vector is a two dimensional with one dimension as a plane of rotation and the other is its line of action. Eg. Angular velocity, angular momentum, torque etc.

1.2 Precession

- The plane of rotation is called precession.
- The precession is caused by a couple or torque acting on a plane perpendicular to the rotation (or spin) of the body.

For precession a torque is necessary:

- Consider a disc DD revolving with a constant angular velocity ω .
- Let the plane of the disc is perpendicular to the plane of paper and axis along YY'
- I - be the moment of inertia
- $I\omega$ - angular momentum
- After precession the disc takes position D'D' making an angle ϕdt with its original position.

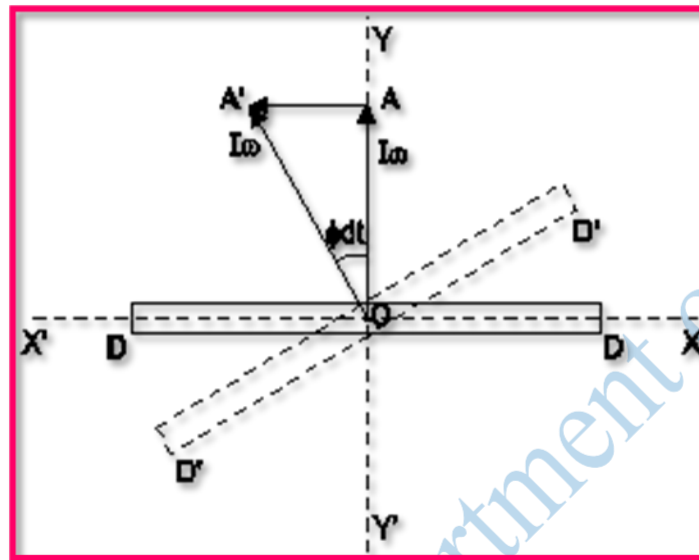
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Then,

The change in angular momentum of the disc is represented vectorially by,

$$\Delta L = I \omega \cdot \phi \, dt$$

This change is done in time dt .

$$\therefore \text{Rate of change of angular momentum of the disc} = \frac{I \omega \phi \, dt}{dt} = I \omega \phi$$

Since, the rate of change of angular momentum of a rotating body is equal to the torque

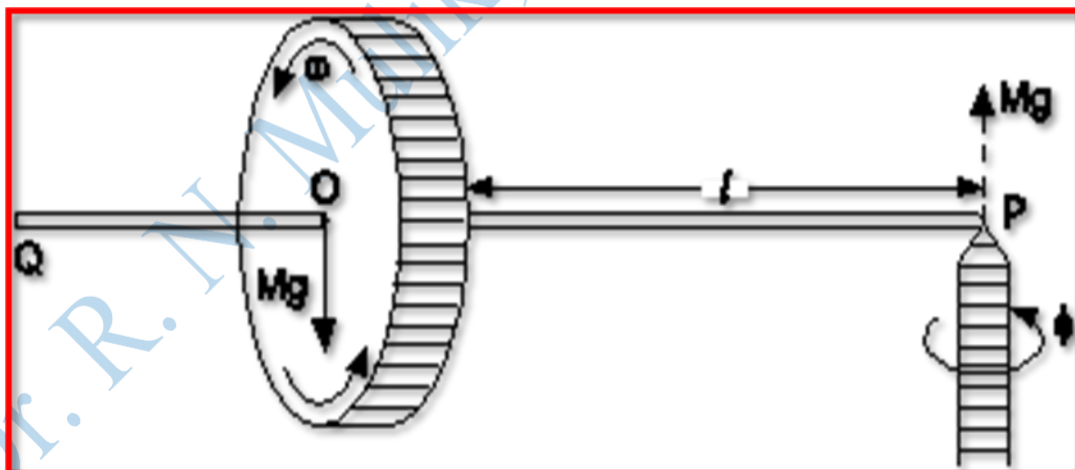
$$\therefore \text{Precessional torque, } \tau_1 = I \omega \phi$$

$$\text{Rate of precession, } \phi = \frac{\tau_1}{I \omega}$$

Thus, the rate of precession is directly proportional to the applied torque τ_1 and inversely proportional to the angular momentum $I \omega$ of the body.

1.3 Gyroscope

- In gyroscope the processional torque needed for processional motion is provided by the gravitational torque τ_2
- Consider a heavy disc D, rotating with high angular velocity ω about an axis PQ, resting on a vertical pivot at point P as shown in Fig.
- Let M be the mass of the disc and Mg is weight of the disc which acts vertically downward.
- This weight exerts a gravitational torque τ_2 on it



$$\tau_2 = Mg \times PO = mg \cdot l$$

when the body is rotating about some axis (PQ), this gravitational torque supplies the necessary precessional torque equal in its magnitude .

$$\tau_2 = \tau_1$$

$$Mgl = I\omega \phi$$

$$\therefore \phi = \frac{Mgl}{I\omega}$$

But $I = Mk^2$, where k is the radius of gyration of the disc about PQ.

$$\therefore \phi = \frac{Mgl}{Mk^2\omega}$$

$$\phi = \frac{gl}{k^2\omega}$$

If t is the time-period of precessional motion, then $t = \frac{2\pi}{\phi}$.

$$t = \frac{2\pi k^2\omega}{gl}$$

It is the time required for one complete cycle of precessional motion.

This type of precessional motion maintained by the gravitational torque is called gyroscopic motion.

1.4 Summery

- The rate of precession is directly proportional to applied torque
- The rate of precession is inversely proportional to angular momentum
- Precessional motion maintained by the gravitational torque is called gyroscopic motion.
- Gyrocompass for navigation of ships and aeroplanes, directional stability of firing bullet etc., the principle of precessional motion is employed.

Homework

Multiple Choice Questions :

1. The change in plane of rotation of a rotating disc is called-----
 - (a) nutation
 - (b) vibration
 - (c) rotation
 - (d) precession
2. In pure precessional motion, nutation is-----
 - (a) absent
 - (b) very small
 - (c) large
 - (d) none of these

3. Gyrocompass is used to determine -----

- (a) angle of dip
- (b) geographic north-south direction
- (c) distance between two places
- (d) magnetic north-south

4. In general the motion of gyroscope consists of-----

- (a) rotation and precession
- (b) only rotation
- (c) rotation, precession and nutation
- (d) only precession

Feedback:

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