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General Physics-I, Quiz 2
PHYS1000AA, Fall Semester-108
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St. ID:______________________, Name:_________________

Chapter 11

1. A uniform solid sphere of radius r = 0.500 m and mass m = 15.0 kg turns counter clockwise about a vertical axis through its centre. Find its vector angular momentum about this axis when its angular speed is 3.00 rad/s.

Ans:

The moment of inertia of the sphere about an axis through its center is

$$I = \frac{2}{5}MR^2 = \frac{2}{5}(15.0\ \text{kg})(0.500\ \text{m})^2 = 1.50\ \text{kg}\cdot\text{m}^2$$

Therefore, the magnitude of the angular momentum is

$$L = I\omega = (1.50\ \text{kg}\cdot\text{m}^2)(3.00\ \text{rad/s}) = 4.50\ \text{kg}\cdot\text{m}^2/\text{s}$$

Since the sphere rotates counter clockwise about the vertical axis, the angular momentum vector is directed upward in the +z direction.

Thus,

$$\boxed{\vec{\mathbf{L}} = (4.50\ \text{kg}\cdot\text{m}^2/\text{s})\hat{\mathbf{k}}}$$

due to the gravitational force on the ball.

2. The angular momentum vector of a precessing gyroscope sweeps out a cone as shown in Figure P11.31. The angular speed of the tip of the angular momentum vector, called its precessional frequency, is given by $\omega_p = \tau/L$, where τ is the magnitude of the torque on the gyroscope and L is the magnitude of its angular momentum. In the motion called *precession of the equinoxes,* the Earth's axis of rotation precesses about the perpendicular to its

orbital plane with a period of 2.58X10^4 yr. Model the Earth as a uniform sphere and calculate the torque on the Earth that is causing this precession.

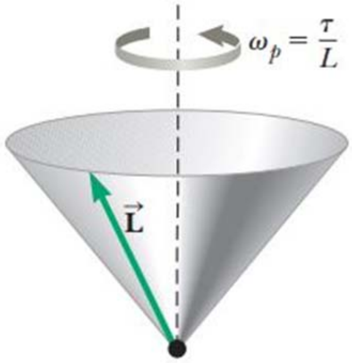

Figure P11.31 A precessing angular momentum vector sweeps out a cone in space.

Ans:

We begin by calculating the moment of inertia of the Earth, modelled as a sphere:

$$I = \frac{2}{5}MR^2 = \frac{2}{5}(5.98\times10^{24}\ \text{kg})(6.37\times10^{6}\ \text{m})^2$$
$$= 9.71\times10^{37}\ \text{kg}\cdot\text{m}^2$$

Earth's rotational angular momentum is then

$$L = I\omega = (9.71\times10^{37}\ \text{kg}\cdot\text{m}^2)\left(\frac{2\pi\ \text{rad}}{86\,400\ \text{s}}\right) = 7.06\times10^{33}\ \text{kg}\cdot\text{m}^2/\text{s}^2$$

from which we can calculate the torque that is causing the precession:

$$\tau = L\omega_p$$
$$= (7.06\times10^{33}\ \text{kg}\cdot\text{m}^2/\text{s})\left(\frac{2\pi\ \text{rad}}{2.58\times10^{4}\ \text{yr}}\right)\left(\frac{1\ \text{yr}}{365.25\ \text{d}}\right)\left(\frac{1\ \text{d}}{86\,400\ \text{s}}\right)$$
$$= \boxed{5.45\times10^{22}\ \text{N}\cdot\text{m}}$$