DEPARTMENT OF PHYSICS
Indian Institute of Technology Kharagpur
Classical Mechanics-I
Course: PH20007
Assignment-8: Assignment-8 (Rigid body dynamics-3)

1. For sphere $I_1 = I_2 = I_3$, it means
   (a) the angular velocity ($\vec{\omega}$) is non zero but the angular momentum ($\vec{L}$) is zero
   (b) the angular velocity ($\vec{\omega}$) is perpendicular to the angular momentum ($\vec{L}$)
   (c) the angular velocity ($\vec{\omega}$) is zero but the angular momentum ($\vec{L}$) is non-zero
   (d) the angular velocity ($\vec{\omega}$) is parallel to the angular momentum ($\vec{L}$)

2. For symmetric top
   (a) $I_1 = I_2 = I_3$
   (b) $I_1 = I_2 \neq I_3$
   (c) $I_1 \neq I_2 = I_3$
   (d) $I_1 \neq I_2 \neq I_3 \neq I_1$

3. During the discussion of heavy symmetric top, we have considered three constants of motion. Two of them were the body z-component of angular velocity and total energy of the system. The third one is
   (a) Total angular momentum
   (b) space z-component of angular momentum
   (c) Kinetic energy of rotation
   (d) body z-component of angular momentum

4. Stable spinning of an asymmetric top may be achieved
   (a) For rotation around an axis with lowest M.O.I.
   (b) For rotation about any arbitrary axis
   (c) For any axis passing through C.M.
   (d) For any rotation velocity perpendicular to horizontal direction

5. If $\Lambda_1, \Lambda_2, \Lambda_3$ and $\omega_1, \omega_2, \omega_3$ are the respective components of the external torque and angular velocity along the principle axes, then the true equation of motion is
   (a) $I_1\dot{\omega}_1 + (I_1 - I_2)\omega_2\omega_3 = \Lambda_1$
   (b) $I_2\dot{\omega}_2 + (I_1 - I_2)\omega_1\omega_3 = \Lambda_2$
   (c) $I_2\dot{\omega}_1 + (I_1 - I_2)\omega_2\omega_3 = \Lambda_2$
   (d) $I_1\dot{\omega}_1 + (I_3 - I_2)\omega_2\omega_3 = \Lambda_1$

6. If T be the kinetic energy, $\vec{G}$ be the external torque about the instantaneous axis of rotation and $\vec{\omega}$ is the angular velocity, then which relation of the following is true
   (a) $\frac{dT}{dt} = \vec{G} \cdot \vec{\omega}$
   (b) $\frac{dT}{dt} = \left|\vec{G} \times \vec{\omega}\right|$

(c) $\frac{dT}{dt} = \frac{1}{2}G\omega^2$
(d) $G\omega = constant$

7. In terms of the Euler angles the components $\omega_1, \omega_2, \omega_3$ of the angular velocity along x', y' and z' axes are given by
(a) $\omega'_x = \omega_1 = \dot{\phi}\ sin\ \theta\ sin\ \psi + \dot{\theta}\ cos\ \psi$
$\omega'_y = \omega_2 = \dot{\phi}\ sin\ \theta\ cos\ \psi - \dot{\theta}\ sin\ \psi$
$\omega'_z = \omega_3 = \dot{\phi}\ cos\ \theta + \dot{\psi}$
(b) $\omega'_x = \omega_1 = \dot{\phi}\ sin\ \theta\ sin\ \psi - \dot{\theta}\ cos\ \psi$
$\omega'_y = \omega_2 = \dot{\phi}\ sin\ \theta\ cos\ \psi + \dot{\theta}\ sin\ \psi$
$\omega'_z = \omega_3 = \dot{\phi}\ cos\ \theta + \dot{\psi}$
(c) $\omega'_x = \omega_1 = \dot{\phi}\ sin\ \theta\ sin\ \psi + \dot{\theta}\ cos\ \psi$
$\omega'_y = \omega_2 = \dot{\phi}\ sin\ \theta\ cos\ \psi + \dot{\theta}\ sin\ \psi$
$\omega'_z = \omega_3 = \dot{\phi}\ cos\ \theta - \dot{\psi}$
(d) $\omega'_x = \omega_1 = \dot{\psi}\ sin\ \theta\ sin\ \psi + \dot{\theta}\ cos\ \psi$
$\omega'_y = \omega_2 = \dot{\psi}\ sin\ \theta\ cos\ \psi - \dot{\theta}\ sin\ \psi$
$\omega'_z = \omega_3 = \dot{\psi}\ cos\ \theta + \dot{\psi}$

8. A rigid body which is symmetric about an axis has one point fixed on this axis. If A is the component of angular velocity in the direction of the axis of symmetry, then the angular velocity vector $\vec{\omega}$ precesses about the angular momentum vector $\vec{\Omega}$ with frequency of
(a) $f = \frac{1}{2\pi}\left|\frac{I_2 - I1}{I_1}\right| A$
(b) $f = \frac{1}{2\pi}\left|\frac{I_2 + I1}{I_1}\right| A$
(c) $f = \frac{1}{2\pi}\left|\frac{I_3 - I_1}{I_1}\right| A$
(d) $f = \frac{1}{2\pi}\left|\frac{I_3 + I1}{I_1}\right| A$

9. Kinetic energy of rotation of a rigid body w.r.t. the principal axes in terms of Euler angles for symmetric top is
(a) $T = \frac{1}{2}I_1(\dot{\phi}^2\ sin^2\theta + \dot{\theta}^2)$
(b) $T = \frac{1}{2}I_1(\dot{\phi}^2\ sin^2\theta + \dot{\theta}^2) + \frac{1}{2}I_3(\dot{\phi}\ cos\ \theta + \dot{\psi})^2$
(c) $T = \frac{1}{2}I_1(\dot{\phi}^2\ sin^2\theta + \dot{\theta}^2) - \frac{1}{2}I_3(\dot{\phi}\ cos\ \theta - \dot{\psi})^2$
(d) $T = \frac{1}{2}I_1(\dot{\phi}^2\ sin^2\theta - \dot{\theta}^2) + \frac{1}{2}I_3(\dot{\psi}\ cos\ \theta + \dot{\psi})^2$

10. For sphere the kinetic energy of rotation of a rigid body refereed to principal axes
(a) $T = \frac{1}{2}I_1(\dot{\phi}^2 + \dot{\theta}^2 + \dot{\psi}^2 + 2\dot{\phi}\dot{\psi}\ cos\ \phi)$
(b) $T = \frac{1}{2}I_1(\dot{\phi}^2 + \dot{\theta}^2 + \dot{\psi}^2 + 2\dot{\theta}\dot{\psi}\ cos\ \theta)$
(c) $T = \frac{1}{2}I_1(\dot{\phi}^2 + \dot{\theta}^2 + \dot{\psi}^2 + 2\dot{\phi}\dot{\psi}\ sin\ \theta)$
(d) $T = \frac{1}{2}I_1(\dot{\phi}^2 + \dot{\theta}^2 + \dot{\psi}^2 + 2\dot{\phi}\dot{\psi}\ cos\ \theta)$

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