Q15. Why does a solid sphere have smaller moment of inertia than a hollow cylinder of same mass and radius, about an axis passing through their axes of symmetry?

Sol: Key concept: Moment of inertia of a particle $I = mr^2$ where r is the perpendicular distance of particle from rotational axis.

Moment of inertia of a body made up of number of particles (discrete distribution)

$I = m_1r_1^2 + m_2r_2^2 + m_3r_3^2$

Moment of inertia of a continuous distribution of mass, treating the element of mass dm at position r as particle

$dI = dmr^2$

MI is not constant for a body. It depends on the axis of rotation.

MI depends on the mass of the body. The higher the mass, higher the MI.

MI depends on the distribution of the mass about an axis. The farther the mass is distributed from the axis, higher will be the MI.

Moment of inertia depends on mass, distribution of mass and on the position of axis of rotation.

All the mass in a cylinder lies at distance R from the axis of symmetry but most of the mass of a solid sphere lies at a smaller distance than R. Therefore,

$I_{hollowcylinder} > I_{sphere}$