1. A rubber ball is dropped from rest onto a linoleum floor a distance $h_1$ away. The rubber ball bounces up to a height $h_2$. What is the coefficient of restitution? What fraction of the original kinetic energy is lost in terms of $\varepsilon$?

2. Find the center of mass of a hemispherical shell of constant density and inner radius $r_1$ and outer radius $r_2$.

3. Calculate the moments of inertia $I_1$, $I_2$, and $I_3$ for a homogenous cone of mass $M$ whose height is $h$ and whose base has a radius $R$. Choose the $x_3$-axis along the axis of symmetry of the cone. Choose the origin at the apex of the cone, and calculate the elements of the inertia tensor. Then make a transformation such that the center of mass of the cone becomes the origin, and find the principal moments of inertia.

4. Consider a thin rod of length $l$ and mass $m$ pivoted about one end. Calculate the moment of inertia. Find the point at which, if all the mass were concentrated, the moment of inertia about the pivot axis would be the same as the real moment of inertia. The distance from this point to the pivot is called **radius of gyration**.

*5. A three-particle system consists of masses $m_i$ and coordinates $(x_1, x_2, x_3)$ as follows:

\[
\begin{align*}
m_1 &= 3m, \quad (b, 0, b) \\
m_2 &= 4m, \quad (b, b, -b) \\
m_3 &= 2m, \quad (-b, b, 0)
\end{align*}
\]

Find the inertia tensor, principal axes, and principal moments of inertia.

*6. A homogenous slab of thickness $a$ is placed atop a fixed cylinder of radius $R$ whose axis is horizontal. Show that the condition for stable equilibrium of the slab, assuming no slipping, is $R > \frac{a}{2}$. What is the frequency of small oscillations? Sketch the potential energy $U$ as a function of the angular displacement $\theta$. Show that there is a minimum at $\theta = 0$ for $R > \frac{a}{2}$ but not for $R < \frac{a}{2}$.

7. A solid sphere of mass $M$ and radius $R$ rotates freely in space with an angular velocity $\omega$ about a fixed diameter. A particle of mass $m$, initially at one pole, moves with a constant velocity $v$ along a great circle of the sphere. Show that, when the particle has reached the other pole, the rotation of the sphere will have been retarded by an angle

\[
\alpha = \omega T \left(1 - \frac{2M}{\sqrt{2M + 5m}}\right)
\]

where $T$ is the total time required for the particle to move from one pole to the other.