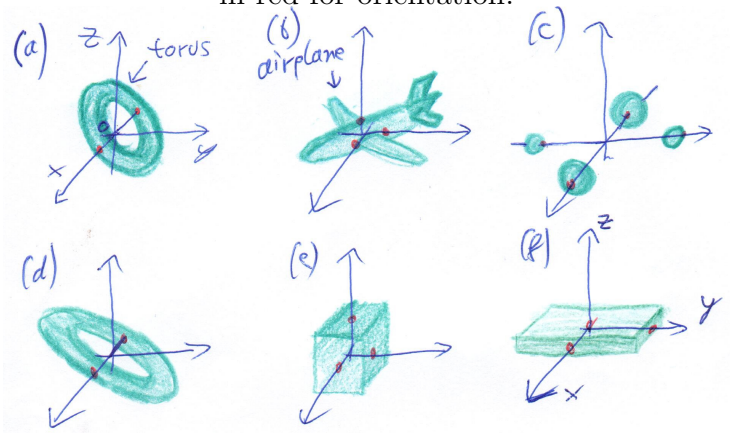
PHY 305, I-Semester 2020/21, Tutorial 6

Work in the same teams as for assignments. Do "Stages" in the order below. Discuss via online (video or audio) conference on a subchannel for your group.

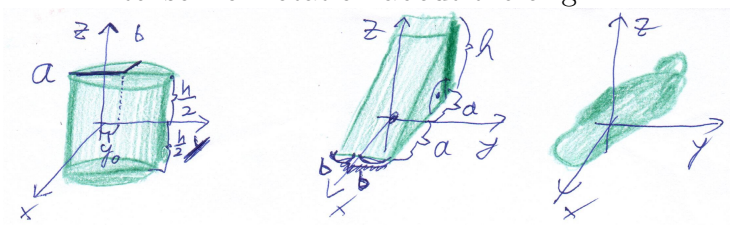
Stage 1 Moment of Inertia tensors without math:

(a) For the following objects (centered on the origin) and rotation axes through the origin, based on what you know from the lecture, find or guess three principal axes and the relative size of the associated moments of inertia. Assume a homogenous solid mass density within the greenish volume. Points where coordinate axes cut through the volume are shown in red for orientation.



top: (a) Regular circular torus. (b) Airplane, with the usual pieces and symmetries. (c) 4 Spheres, 2 large, 2 small, all the same distance from the origin. (d) Ellipsoidal torus, with smaller radius along x-axis. (e) Symmetric cube. (f) Cuboid, with withs along axes $w_z < w_x < w_y$.

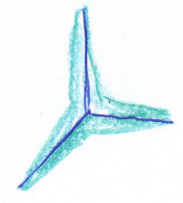
(b) For the following objects, list all obviously zero elements of the inertia tensor for rotation about the origin.



top: (a) Cylinder with ellipsoidal cross section of indicated semi-minor axis b and semi-major axis a, around centre point at $x_0 = 0$ $y_0 > 0$ as shown. (b) Triangular block. (c) Asteroid toutatis (see lecture notes) in random orientation.

Stage 2 Discuss what are Euler angles and what are body fixed and space fixed frames. Then assemble an experimental tripod of coordinate axes as for the figure on top of page 73. Maybe out of one corner of a cardboard carton (see figure below), or by attaching three spoons at right angles. Then use that to implement three separate Euler angle rotations and convince yourself that

this can get you from any orientation of your axes to any other orientation.



left: Axes tripod out of cardboard carton corner.

Stage 3 Discuss what is meant by precession and nutation of a heavy top, and why either of them happens. Then try to find or buy a children's top, or some object that can function as one (symmetric in xy, bit bulgy in z, heavy and rigid enough). Try to reproduce precession or nutation as discussed in the lecture. The heavier your top the better, as light ones might be dominated by effects we had not included, such as friction on the table. If your top works well, make a video and share it with others. If your top does not work well, or you could not acquire one, use this online app instead.