Part1:

Maximum tumbling is observed when the angular velocity about the x- axis is the greatest, then the y axis and then the z axis(wx>wy>wz). From the intermediate axis theorem and by trial and error on our simulation, it is observed that the x- axis is the 'intermediate' or the least stable axis. From the simulation we observe quick rotations about the shortest sides of the artifact, while the object twists more slowly about its longer sides.

Part2:

Part2A:
The center of mass of the object was found using the optimization code provided. The methodology employed found the point in the centre of the markers that stayed the same distance from the markers as the object moved. The initial location and linear velocity of the center of mass were found to be [-11, 0, 0] and [0.02, -0.05, 0.01], respectively. The orientation of the object was found using the relative rotation of a coordinate system constructed using one of the object's corner markers as the origin.The other edges that passed through it were used as axes. The rotation of this coordinate system was separated from the translation component and compared to the initial orientation of the frame.The resulting rotation matrix was then converted to quaternions. The resultant positions and orientations over time have been listed out in problem_2_0.dat.

Part2B:
The angular velocity of the object was found by converting the quaternions into XYZ Euler angles. The difference between each set of Euler angles over time is the angular velocity of the object. The angular velocities can be found in problem_2_1.dat.

Part2C:
The angular acceleration of the object was found by taking the difference for of the angular velocities of the object over the time step, which were calculated in part 2B. The calculated accelerations are recorded in problem_2_2.dat.

Part2D:
The moments of inertia of the principle axes are: **Iyy = 0.4359, Ixx = 0.5199, and Izz = 0.7346.** The other moments of inertia are given by: **[0.5199 0.0050 0.0053;0.0050 0.4359 0.0027;0.0053 0.0027 0.7346]**.These moments of inertia were found by separating the components of the torque equation into two matrices, one with the angular velocity and acceleration terms and one with the moments of inertia (**torque = I w_dot + w x I w**). The matrix with the known terms was solved for the points used in part 2a resulting in a stack of resultant 3x6 matrices. The smallest eigenvalue of the 450x6 matrix of points was found using SVD, with the corresponding V vector representing the moments of inertia. The rotation matrix representing the original rotation between the principal axes and the assignment coordinate

axes is **[0 0 1;1 0 0;0 −1 0]** or, in quaternions, **[0.6479, -0.7563, -0.0883, -0.0201]**(calculated in 2A).

Part2E:

The future position of the center of mass of the artifact was found by shifting the previous position by the velocity multiplied by the time step for each time step from 10 – 20 seconds. The rotation was found by using Euler integration; the derivative of the rotation matrix is **Rdot =** $S(\omega)R$, with S = [0 $-\omega z$ ωy;ωz 0 $-\omega x$;$-\omega y$ ωx 0].The angular velocity was also found using Euler integration and the angular acceleration was found by solving the torque equation at each time step: $I\alpha + \omega \times I\omega = 0$. The resultant position and rotation data have been recorded in problem_2_3.dat.

Part3:

The location for the artifact in world coordinates was found using the rotation matrix found in part 2d and the original location of the lander. The resulting transformation matrix was combined with the artifact coordinates according to the lander to find the artifact coordinates in the world. The rotation was found by combining the rotation quaternion found in part 2d with the viewed quaternion. Seems like there is something wrong with either my approach or some other aspect of my code which I have not been able to figure.“problem_3.dat” has the recorded values for the code I have written so far..