Physics 321
Sample Final Questions

● Part 1 will consist of four questions: two each from Review 1, Review 2, Test 1, or Test 2.

1. You are asked to find the inertia matrix for a prolate spheroid. Describe how you do this. (You should describe the integrals you need and write down a general form for them, but you not need to try to include actual limits of integration.) In addition to the density of the spheroid, what other information do you need to know before you can find numerical answers?

2. The following is an inertia matrix for an object. Describe in detail, how you can use Maple to find the principal axes and the moments of inertia about those axes.

$$\mathbf{I} = \begin{bmatrix} \frac{1}{12}ma^2 & -\frac{1}{6}mab & -\frac{1}{48}mac \\ -\frac{1}{6}mab & \frac{1}{4}mb^2 & -\frac{1}{24}mbc \\ -\frac{1}{48}mac & -\frac{1}{24}mbc & \frac{1}{3}mc^2 \end{bmatrix}$$

3. Two objects made out of the same plastic material have the same inertia tensors. Must they be of identical shape? Explain.

4. A lamina has moments of inertia I_{11} and I_{22} about the two axes that lie in the plane of the lamina. What is the moment of inertia about the axis perpendicular to the lamina? How do you know?

5. Why are principal axes useful?

6. Euler's Equations can be written in the form $\dot{\vec{L}} + \vec{\omega} \times \vec{L} = \vec{\Gamma}$. What does this mean? Why is it that Euler's equations are often very difficult to use?

7. Euler's Equations can be written in the form $\dot{\vec{L}} + \vec{\omega} \times \vec{L} = \vec{\Gamma}$. Write down the equations of motion for the general motion of a football in empty space. (Assume the football has cylindrical symmetry.). It is immediately evident from these equations that what quantity is conserved?

8. Name and describe three constants of motion for the motion of a frisbee in space axes. (Ignore drag and aerodynamic effects.)

9. What is the Inermediate Axis Theorem?

10. Describe Euler's angles. If each of the Euler angles is 90°, how is a body oriented with respect to the space axes?

11. Describe in words the motion associated with $\dot{\phi}, \dot{\theta}, \text{and } \dot{\psi}$.

12. In the motion of a top, we found that two variables were ignorable. Which variables were these? What are the conserved momenta associated with each of these variables?

13. What is meant by nutation of a top? Nutation depends on which angular velocities?

$(\dot{\phi}, \dot{\theta}, \text{or } \dot{\psi}?)$ Decribe the different types of nutation that are encountered in the motion of a top.

14. Three objects are connected to each other with springs. They are constrained to move without friction in one dimension. Each object has a different mass. Describe how you go about finding the normal modes of oscillation for this system. How would you find the frequencies of oscillation for the normal modes?

15. If two pendula are connected with a weak spring, describe the motion of the system that ensues when you displace one pendulim and let it go from rest.

16. What is a normal mode of oscillation? Why is it useful to know what the normal modes are for a coupled oscillator?

17. What are three characteristics of nonlinear oscillators that are often encountered?

18. Are all nonlinear oscillators chaotic? How can you experimentally tell if the motion of a system is chaotic?

19. What is state space (phase space) plot? Why are such plots useful in analyzing the motion of a nonlinear oscillator?

20. Describe the method of successive approximations in solving for the motion of a nonlinear oscillator. What important character of nonlinear oscillators does this process exemplify?

21. How do we transform equations of motion from one inertial frame to another?

22. Why is it useful to discuss collisions in the center of mass frame?

23. Describe how we can find the velocity of the center of mass frame.

24. Define the differential cross section for a scattering experiment in which the target is bigger than the beam.

25. For a given process, the differential cross section is isotropic (it has no angular dependence) and has a value of 27.2 mb/sR. What is the total cross section? How do you know?

26. Why is it important to know the relationship between the impact parameter and the scattering angle in order to calculate the cross section of a process?