1. A particle is in a state ψ_{lm} with definite values of the orbital angular momentum and its projection on the z axis. Find the average value of the projection of the angular momentum on axis z', which makes angle α with z.

   Hint: Express operator $L_{z'}$ in terms of L_x, L_y, and L_z. You might also want to recall the relations derived in problem 2 of the previous homework.

2. A particle is in a state that has the following angular dependence (the standard spherical coordinates are used):
   $$\psi(\theta, \phi) = A \cos^n \phi,$$
   where A is a constant and n is an integer. If the projection of the orbital angular momentum on the z axis is measured, what is the probability of obtaining value $m\hbar$?

   Hint: Calculations might be easier if you express the cos function as a sum of two exponents and recall the binomial expansion.

3. The angular momenta of two particles with $L_1 = 1$ and $L_2 = 2$ are coupled. The Hamiltonian of the system is $\hat{H} = \varepsilon \, \mathbf{L}_1 \cdot \mathbf{L}_2$, where ε is a positive constant. Find all energies and their degeneracies.

4. Problem 4.45 in Griffiths.