Question 1

How do vectors in 3D Euclidean space, wave functions defined on that space, and operators on these wave functions transform under a rotation of angle $\phi$ around axis $\hat{n}$?

$$r \rightarrow r' = r + \hat{n} \times (\hat{n} \times r)(1 - \cos \phi) + \hat{n} \times r \sin \phi$$

$$f(r) \rightarrow F(r) = U_R f(r) = e^{\frac{2\pi i}{\hbar} \hat{n} \cdot \mathbf{L}} f(r)$$

$$\mathbf{A} \rightarrow \mathbf{A}' = U_R \mathbf{A} U_R^\dagger$$

Question 2

What is the definition of an angular momentum in quantum mechanics (no more, no less)?

Three Hermitian operators satisfying the commutation relation:

$$[J_i, J_j] = i\hbar \epsilon_{ijk} J_k.$$

Question 3

Why is it advantageous to express the orbital angular momentum problem in spherical coordinates and what is the solution to the problem?

It is advantageous to do so because the radial coordinate drops out of all the angular momentum expressions. The eigenfunctions of the $L_z$ operators are the functions $\Phi_m(\phi) = e^{im\phi}$ with eigenvalues $m\hbar$ and the eigenfunctions of the $L^2$ operator are the spherical harmonics $Y_l^m(\theta, \phi)$ with eigenvalues $l(l + 1)\hbar^2$.

Question G

What remarkable (surprising, insightful, powerful, dubious) statement(s) did you find in your reading of Merzbacher’s Chapter 11? What exactly do you find remarkable about the statement(s)?

Question H

Which exercise and which problem from Merzbacher’s Chapter 11 would you like to be in charge of solving? Why?