1. Problem 34-53 from HRK \( (\text{see below}) \)

2. For the Hydrogen Atom ground state find the radius at which the probability for finding the electron is a maximum.

3. This problem is based on the “B92” method of quantum key distribution. 

Photons are directed at a polaroid sheet held by Alice.
The Transmission Axis (TA) of Alice’s sheet is either vertical (V) or at 45°.
When Alice wants to send a “1” bit she uses the 45° orientation and when she wants to send a “0” bit she uses the V orientation.

Some distance away Bob has two polaroid sheets.
His polaroid TA can be either horizontal (H) or at \(-45°\).
When Bob uses his H sheet he assigns a “1” bit to any photon he observes.
When Bob uses his \(-45°\) sheet he assigns a “0” bit to any photon he observes.

   a) For each of the two types of photons that Alice can send make a table showing what Bob sees with each of his two polaroid orientations.
   For each case give the probability that Bob sees a photon.

Bob and Alice keep the bits for which Bob saw a photon and they use these as the key. In this method they never discuss the polaroid orientations but just note the cases where Bob observed a photon.

   b) Show that for the \textit{kept} subset of bits Bob and Alice agree on the bit values.

   c) Alice and Bob choose their polaroid sheets at random. What fraction of bits sent by Alice will be seen by Bob and therefore used?

   d) What happens if an eyesdropper Eve, places a polaroid sheet (for example in the H direction) between Alice and Bob.
   What fraction of photons will Alice and Bob agree on now?

4. The state of a spin \( \frac{1}{2} \) system is \( \frac{1}{\sqrt{2}} (|+\rangle - |--\rangle) \) in the \( z \) basis.
   a) Calculate the expectation values of \( S_x, S_y, S_z \).
   b) Which way does the spin point? (in a classical sense).
   c) A beam of such particles travels in the \( +y \) direction. A Stern-Gerlach device (SG) separates the \( z \) components of magnetic moment. What are the relative intensities coming out of the SG device?

   Same question but the SG device separates \( x \) components.

   d) Suppose now that a beam of particles was formed by mixing, equally, particles known to have spin “up” in the \( z \) direction and particles known to have spin “down” in the \( z \) direction. Would any of the results of part c) be different? If so, how? Explain.