PHY 342 HW Ch.4b

Do problem 4.10*, 4.11, 4.15 plus the following (*=optional bonus).

q4.5
For the particle in the 3D infinite spherical well, the wave function for $l = 0$ (s-state) is

$$\psi_{n00} = A\frac{\sin(n\pi r/a)}{r}Y_{00}.$$

Determine the normalization constant A.

q4.6
For $l \neq 0$ states in the 3D infinite spherical well, the eigenenergies are determined by the zeros of $j_l(ka)$, or $k_{nl} = x_{nl}/a$ with x_{nl} being the n-th zero of the spherical Bessel function $j_l(x)$.
Search for "Scipy zeros spherical Bessel function", or follow this link
`https://docs.scipy.org/doc/scipy/reference/generated/scipy.special.spherical_jn.html`
to write a program to obtain graphically (or numerically with root finding) the first 5 zeros of $j_l(x)$ for $l = 1, 2, 3$. Then give the energies E_{nl} for each l in units of $\hbar^2\pi^2/2ma^2$. Sketch the energy levels, with n being the vertical axis and l the horizontal axis including $l = 0$.

q4.7
(a) Plot the radial wave functions R_{20} and R_{21} using a computer. Omit the $a^{-3/2}$ factor, and use Bohr radius as the units for r.
(b) Plot the radial probability distributions, i.e., $|R_{nl}|^2r^2$, for the two cases. Restrict $0 \leq r/a \leq 10$.

q4.8
Derive the most probable value of r for finding the electron in the states R_{20} and R_{21}. Note this is different than the highest probability density. Compare and discuss your answers with the graphs above.