Phys106, II-Semester 2018/19, Tutorial 11, Fri 12.4.

Work in teams of three. Do "Stages" in the order below. When all teams finished a stage, make sure all students at your table understand the solution and agree on one by using the board.

Stage 1 Catch-up: Do all steps of tutorials 8-11 that you have not yet done earlier or have not fully understood. Read their solutions. Ask us questions about those. In particular, explore the TDSE app at http://www.falstad.com/qm1d/ .
If that has a too confusing array of functionalities, there are simpler ones for the square well http://physics.weber.edu/schroeder/software/SquareWell.html and the quantum harmonic oscillator
http://physics.weber.edu/schroeder/software/HarmonicOscillator.html .

Stage 2 Hydrogen atom:

(i) Angular momentum quantisation: Revise /read up on angular momentum (or ask us). Then draw a picture such as the one on the slide with Eq. (132) for the case of an angular momentum with quantum number $l = 4$.

(ii) Watch the following video on the precession (slow axis tilting) of a spinning top: https://www.youtube.com/watch?v=sHnDzGWcqlQ . Connect this to the discussion in the lecture of the uncertainties involved in angular momentum quantisation.

(iii) Follow the lecture discussion of the Hydrogen wave-functions $\Psi_{nlm}(r, \theta, \phi)$ for $n = 1$, $n = 2$ and all possible l, m. Write the wavefunction as equation and then make drawings. Make more drawings than in the lecture, look at cuts through the xy plane and xz plane. Use the board for this.

(iv) Now extend the equation writing and drawing to the $n = 3$ states. Their equations are:

$$\Psi_{300}(r, \theta, \phi) = \mathcal{N} \underbrace{\left(27 - 18\frac{r}{a_0} + 2\frac{r^2}{a_0^2}\right) \exp -r/3a_0}_{\equiv f_{30}(r)}, \tag{1}$$

$$\Psi_{310}(r, \theta, \phi) = \mathcal{N} \underbrace{\left(6 - \frac{r}{a_0}\right) \frac{r}{a_0} \exp -r/3a_0}_{\equiv f_{31}(r)} \cos\theta, \tag{2}$$

where $\mathcal{N}$ are (possibly different) normalisation factors.
For your drawing you may use the following plots of the radial part of the wavefunction: TA Please drawn scan and add $n = 3$ radial wavefunctions for all possible l. With caption.