For these problems, use the simulation “The expectation value” in the QuVis HTML5 collection.

1) Have a play with the simulation for a few minutes, getting to understand the controls and displays. Note down three things about the controls and displayed quantities that you have found out.

2 a) Consider the input state $\sqrt{\frac{3}{10}}|\uparrow> + \sqrt{\frac{7}{10}}|\downarrow>$ shown in the simulation. Experimentally find the detection probabilities for particles to be detected in the upper path and in the lower path after passing through the Stern-Gerlach apparatus. Explain how these detection probabilities can be theoretically calculated from the input state.

b) Do the same for the input state $\frac{1}{\sqrt{5}}(-2|\uparrow> + |\downarrow>)$.

c) Find the absolute value of the coefficients $|a|$ and $|b|$ for the third input state. Explain your reasoning. Why can you only find $|a|$ and $|b|$ and not a and b?

3) a) Explain the two procedures shown in the Expectation value (I) and Expectation value (II) panels to experimentally determine the expectation value $< \hat{S}_z >$ of the z-component of spin for a fixed input state. Show that the two procedures must give the identical result and are thus equivalent.

b) Will your value for $< \hat{S}_z >$ obtained experimentally exactly agree with the theoretical value? Explain using the simulation.

4) Consider the input state $\sqrt{\frac{3}{10}}|\uparrow> + \sqrt{\frac{7}{10}}|\downarrow>$.

a) What are the possible outcomes for a single measurement of S_z?

b) What is the most likely outcome of S_z for a single measurement? Explain how you can determine this most likely outcome for a single measurement from the theoretical probability Prob_+.

c) Explain how you can determine the most likely outcome of S_z for a single measurement from the theoretical expectation value $< \hat{S}_z >$.

5) Come up with an input state different to those shown in the simulation for which

a) the theoretical expectation value $< \hat{S}_z > < 0$.

b) the most likely outcome of S_z for a single measurement is $+\hbar/2$.

c) $+\hbar/2$ and $-\hbar/2$ are equally likely outcomes of S_z for a single measurement.