

### 1 Spin One Half Unknowns (Brief)

Using the SPINS simulation for a spin- $\frac{1}{2}$  system (Spins simulation), for the unknown initial state  $|\psi_4\rangle$ , perform measurements of  $S_x$ ,  $S_y$ , and  $S_z$  separately, and for each measurement determine the probability of obtaining each possible measurement value. (We carried out the same procedure for  $|\psi_3\rangle$  in class; you may refer to that example.)

- (a) Use the probabilities you observed from the measurements to express  $|\psi_4\rangle$  as a linear superposition of the  $S_z$ -basis states  $|+\rangle$  and  $|-\rangle$ .
- (b) *Articulate a Process:* Write a set of general instructions that would allow another student in next year's class to find an unknown state from probabilities obtained from spin measurements.
- (c) *Compare Theory with Experiment:* Design an experiment that will allow you to test whether the state you identified in Question (a) for the unknown state  $|\psi_4\rangle$  is correct. Describe your experiment here, clearly but succinctly, as if you were writing it up for a paper. Do the experiment and discuss your results.
- (d) *Make a Conceptual Connection:* In general, are the probabilities obtained from spin-component measurements along only two spin directions (for example, the  $z$  direction and the  $y$  direction) sufficient to determine a spin- $\frac{1}{2}$  quantum state? Why or why not?