PHYS 5382 Exam 1

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Printed Name ______________________________

DIRECTIONS:

1. If I can't read it, I can't grade it.

2. **Show** your work to receive credit.

3. **BOX YOUR FINAL ANSWERS**

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5. Paginate all pages. Label the problem number clearly.

6. Staple your pages together, in order.

7. Good luck.

Q1 2 pts. What is the value of $\hbar$? Include proper units along with the number and **box** the complete answer.

Q2 2 pts. Express the derived unit Joule J in terms of the basic SI units for mass, kilogram. etc. Your answer ahould be of the form $\boxed{\text{J} = \text{some SI units}}$. Standard abbreviations are ok. Yes, you still need to **box** your answer.

Q3 16 pts. Consider a beam of neutral silver atoms whose spin state $|\Psi\rangle$ is described by

$$|\Psi\rangle = \frac{1}{2}\,|+\mathbf{z}\rangle + \frac{i\sqrt{3}}{2}\,|-\mathbf{z}\rangle \ .$$

a.) 1 pt. What is the intrinsic angular momentum S of the outermost electron of a neutral silver atom? Write your answer as $\boxed{\text{S} = \text{your answer}}$. Note the box.

b.) 5 pts. The beam is sent through a "z-style" Stern-Gerlach device. What is the probability $P(-z)$ of measuring an atom's spin to be aligned along the negative z-direction? Show your work and box the answer.

c.) 5 pts. The original beam is now sent through an "x-style" Stern-Gerlach device. What is the probability $P(+x)$ of measuring a silver atom's spin to be aligned along the positive x-axis? Show your work and box the answer.

d.) 5 pts. Calculate explicitly the inner product $\langle\Psi|\Psi\rangle$. Box the answer.

Q4 15 pts. Determine the matrix representation of $\hat{J}_y$ in the S_x basis. Hint: This is easily done by first writing the matrix representation of $\hat{J}_y$ in the y-basis and then transforming to the x basis. You will eventually need to compute various inner products (e.g., $\langle +\mathbf{x}|+\mathbf{y}\rangle$) involving bras and kets like $|+\mathbf{x}\rangle$, $\langle +\mathbf{y}|$, etc. This is best done using the states

$$|+\mathbf{x}\rangle = \frac{1}{\sqrt{2}}|+\mathbf{z}\rangle + \frac{1}{\sqrt{2}}|-\mathbf{z}\rangle \qquad |-\mathbf{x}\rangle = \frac{1}{\sqrt{2}}|+\mathbf{z}\rangle - \frac{1}{\sqrt{2}}|-\mathbf{z}\rangle$$

and

$$|+\mathbf{y}\rangle = \frac{1}{\sqrt{2}}|+\mathbf{z}\rangle + \frac{i}{\sqrt{2}}|-\mathbf{z}\rangle \qquad |-\mathbf{y}\rangle = \frac{1}{\sqrt{2}}|+\mathbf{z}\rangle - \frac{i}{\sqrt{2}}|-\mathbf{z}\rangle .$$

Q5 4 pts. You construct a collimated beam of neutral, unpolarized silver atoms in the lab. You send the beam through a y-style Stern-Gerlach device. On the exit side of the device, you block completely the beam polarized along the +y direction. You next send the remaining beam (polarized along the -y direction) into an x-style Stern-Gerlach experiment. What is the probability P of observing the beam to be polarized along the +x direction? Box the answer.

Q6 6 pts. Consider a beam of neutral silver atoms whose spin state $|\Psi\rangle$ is described by

$$|\Psi\rangle = \frac{1}{5}\,|+\mathbf{z}\rangle + \frac{-i2\sqrt{6}}{5}\,|-\mathbf{z}\rangle\ .$$

Calculate $\langle S_y \rangle$. Show your work and box your answer.